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ABSTRACT

In an interdisciplinary project graduate students from several fields--including medicine and communication--conducted an assessment and critique of media performance in the are of environmental problems. The project had no direct faculty supervision--the first such student project funded by the National Science Foundation. This volume presents an extensive background on the various environmental problems in the San Francisco Bay Area. Specific attention is paid to the political history of the California State Water Project, the water resources in the Bay Area, the problem of optimal resource allocation, and the unique quality of the San Francisco Bay. Comprehensive waste water management plans in the San Francisco Bay Area are surveyed and an examination is made of the environmental problems of the Monterey Bay Area. The question of access to information on nuclear power plant siting is also discussed at some length. For a study of the role of the media in these environmental problems see volume two (EM009437). (JY)

MASS MEDIA AND THE ENVIRONMENT

SAN FRANCISCO AND MONTEREY BAY WATER RESOURCES

VOLUME NO. 1

PROJECT DIRECTORS:
DAVID PETER SACHS & DAVID MARK RUBIN

ED 058709

MASS MEDIA AND THE ENVIRONMENT

Volume I

SAN FRANCISCO AND MONTEREY BAY WATER RESOURCES

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Stanford University

September 1971

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ILLUSTRATIONS

PREFACE

This research project, on the general subject, "Mass Media and the Environment," is unusual in three respects. First, it is an interdisciplinary project linking two fields — medicine and communication — which are not usual partners. Second, it is an experiment by the National Science Foundation in granting research funds directly to graduate students and permitting them to oversee a research project without direct faculty supervision. And third, while it is in part an assessment and critique of media performance, both disciplines offer much information which we hope can be put to use immediately by the press and concerned public to help solve environmental problems.

For their faith in this effort we would like to thank Miss Joan Callanan of the Division of Graduate Education in Science at the National Science Foundation and Dr. Fred Honkala, formerly Director of that Division and now President of Yankton College in South Dakota. For their sponsorship and guidance we thank Professors Joshua Lederberg (Genetics) and William Rivers (Communication), Don Stuedeman, administrative officer of the Genetics Department, Niels Reimers, of Stanford's Research Administration Office, and Frank Newman of the University Relations Office. We have particularly appreciated the energy and overtime which Tom Sakamoto, Grace Bartholomew, Richard Brown, and others in the Stanford Reprographics Office willingly and calmly gave to publish these volumes on time. And for their devotion to the project we thank all the Stanford students — and their wives and husbands — who worked long hours to bring it to a successful conclusion.

David Peter Sachs
David Mark Rubin

Stanford University
10 September 1971

PROJECT PARTICIPANTS

Although this volume has been edited as a single product, it represents 14 months of dedicated work by 15 individuals from various graduate and undergraduate departments at Stanford. The following brief curriculum vitae are provided for readers curious about the identities behind our editorial "we," and for those who may wish to assign praise or blame for work in specific chapters.

DAVID PETER SACHS: PROJECT DIRECTOR AND CO-PRINCIPAL INVESTIGATOR (B.A., Biology, Carleton College, '67). Mr. Sachs's interest in the environment began in 1958 – long before it was a household word – with an in-depth study of Lake Erie's pollution and eutrophication. During the course of this work he evaluated various water treatment techniques and developed a simple, chemical method for removing synthetic detergents from water supplies. In 1964, he received an award from Eastman Kodak for a 16mm, color and sound film on insect ecology. At Stanford he has conducted and published original biochemical research. He has also published pieces on water quality and occupational health problems in *McCall's* and *Saturday Review*, and was a contributor to the Sierra Club's *Ecotactics*. He has additionally taught numerous Stanford undergraduate seminars on urban problems and the environmental impact on health. In June 1972, he will finish the five-year M.D. program at Stanford, prior to internship and a career in medicine. In addition to his academic pursuits, he is an accomplished French horn and pipe organ player. He is responsible for the overall research program which the Ecological Medicine team carried out and for the final form and editing of this volume. He contributed the material in Chapter I and IX as well as the first part of Chapter IV and the discussion of the coliform test in Chapter VII.

DAVID MARK RUBIN: CO-PRINCIPAL INVESTIGATOR AND PROJECT DIRECTOR FOR VOLUME II (B.A., History, Columbia, '67; M.A., Communication, Stanford, '68). A former director of Columbia's WKCR-FM in New York, Mr. Rubin has also worked for the Cleveland *Plain Dealer*; Elyria (O) *Chronicle-Telegram* (on a *Wall Street Journal* Newspaper Fund Scholarship), and the San Francisco *Chronicle* (as Stanford stringer for the Sporting Green). He has published in *Columbia Journalism Review* and *California Newspaper Publisher*, and he is co-author with Stanford Professor William L. Rivers of *A Region's Press*, a critical look at the Bay Area's newspapers. He is currently authoring a mass media introductory textbook for Prentice-Hall with Peter M. Sandman and David B. Sachsman. He will be an assistant professor in the Journalism Department at New York University (Washington Square) in 1971-72. He contributed the material in Chapter VIII on nuclear power plant siting, which is part of his dissertation for the Doctorate.

ADRIAN ARIMA. Mr. Arima is a Stanford undergraduate in a double degree program. At its conclusion in June 1972, he will receive a B.A. in economics and an M.S. in operations research. He has been active in undergraduate activities at Stanford and contributed to a report on transportation planning published by the Stanford Workshops on Political and Social Issues. Following his June graduation he is contemplating combining these varied interests in law school. Mr. Arima contributed material in the first part of Chapter VII dealing with Monterey Bay pollution.

MICHAEL JUDSON BEVIER (B.A., Government, Carleton College, '66; M.B.A., Stanford, '71; J.D., Stanford, '71). Mr. BeVier spent a portion of the 1965 Carleton academic year as an intern in Washington, D.C., where he studied pressure group activity during passage of the Office of Economic Opportunity Act. He graduated from Carleton Phi Beta Kappa. As a Stanford Law and Business School student he was managing editor of the *Stanford Journal of International Studies* and published in that journal. He also conducted a detailed investigation into the control of automobile air pollution in California. Mr. BeVier contributed

many of the ideas in the first part of Chapter IV in which he applied his old interest in welfare economics to regulation of environmental pollution.

STEPHEN PAUL FORTMANN (B.S., Biology, Stanford, '70). Mr. Fortmann is currently a second year student in the M.D. program at the University of California at San Francisco Medical School. During 1969-70 he was Vice-President of the Stanford Conservation Group. Additionally he spent an academic quarter investigating the DDT contamination of commercial fishes at Stanford's Hopkins Marine Station. Mr. Fortmann organized many parts of Chapters V and VII and generally reviewed the biological concepts expressed in this volume for accuracy and completeness.

DANIEL EVERETT GREEN. A senior biology major at Stanford, Mr. Green has carried out extensive studies regarding Katydids on Stanford's Jasper Ridge Biological Preserve and plans to enter medical school next year. He contributed much of the technical material regarding sewage treatment in Chapter VII.

GLENN ROPERT LOPEZ (B.A., Biology, Stanford, '71). Currently a graduate student in marine biology in the Division of Ecology and Evolutionary Biology at the State University of New York at Stony Brook, Mr. Lopez served as project coordinator for the water resources phase of this study. In 1969 he was co-chairman of the first statewide Student Environmental Congress, held at Stanford. During the summer of 1970 he obtained a fellowship from the Institute for the Study of Health and Society, in Washington, D.C., where he co-authored a handbook on the Army Corps of Engineers. Spring quarter, 1971, Mr. Lopez conducted research at the Hopkins Marine Station on heavy metal concentrations in plankton. He contributed the materials in Chapters III and VI, discussing water resources in the Bay Area and waste water disposal plans. Additionally he edited Chapter V and provided some of the general discussion about estuaries.

LLOYD W. LOWREY, JR. (B.S., Agricultural Business Management, University of California at Davis, '68; J.D., Stanford, '71). Mr. Lowrey has been exceptionally active in the Stanford Environmental Law Society and helped prepare several studies for this group on air pollution, water use, and land development. He will work for the General Counsel's Office of the U.S. Postal Service prior to entering the Army Judge Advocate General Corps. Mr. Lowrey wrote Chapter II discussing the political history of the California Water Plan.

ELLEN MARIE MACKE. A senior sociology major, with special emphasis on law and urban affairs, Ms. Macke is especially interested in the interpersonal and societal problems which cities generate. Following graduation from Stanford she is considering entering law school. During this past year she has been conducting a detailed study of child care facilities in the City of San Francisco. This project will continue during the coming year. Ms. Macke reviewed many of the ideas in Chapters I, III, IV, and IX and provided helpful comments for expressing them more clearly.

MARY ANNE MARK (B.S., Physics and M.S., Physics, City College of New York, '63 and '65). An avid mountain climber and conservationist, Ms. Mark was a research physicist at the Lawrence Radiation Laboratories in Livermore for four years until job cutbacks began last year. She has received a traineeship from the Environmental Protection Agency and this fall will begin graduate study in environmental engineering in Stanford's civil engineering department. With her husband, Robert Mark, she prepared the material in Chapter V discussing the physical effects of reduced fresh-water flow to the San Francisco Bay-Delta.

ROBERT KENT MARK (B.S., Physics, City College of New York, '64; M.S., Physics, Stanford, '69). Completing graduate work for the Ph.D. in geology at Stanford, Mr. Mark is both a member of Phi Beta Kappa and Sigma Xi. He is an avid outdoorsman and peak climber and has been very active in the Sierra Club, serving on its Executive Committee from 1968 to 1970. He helped found the Stanford Conservation Group in 1966. Mr. Mark plans to continue in a professional career as a geologist, remaining in the Bay Area. With his wife, Mary Anne Mark, he prepared the material in Chapter V discussing the physical effects of reduced fresh-water flow to the San Francisco Bay-Delta.

BRUCE MARTIN. An undergraduate art major at San Francisco State College, Mr. Martin's program also has heavy emphasis on biology, since he plans to become a medical illustrator. He created the covers for Volumes I, II, and III in this series and the cover for *The Politics of Pollution Control in Monterey Bay* as well as providing the majority of the graphic art work for these volumes, including the detailed maps in Volume I.

LEWIS PALMER (B.A., Biology, Stanford, '71). Mr. Palmer has had a long-standing interest in fisheries biology and has frequently written about northwestern California. During the coming year he plans to conduct medical research, with a view toward entering medical school one year hence. Mr. Palmer wrote the last part of Chapter IV discussing the impact of the State Water Project on Northern California's fish and wildlife.

ANN YOUNG WATSON. Ms. Watson has been involved with a number of interesting academic and research programs at Stanford. A senior human biology major, she recently co-authored the book entitled *Pesticide Exposure and Protection of California Farm Workers.* Working at the Stanford Medical Center, she has conducted basic research employing electron microscopy and is currently engaged in research in the pediatrics Department there. Ms. Watson contributed the detailed material in Chapter V dealing with the biology of estuaries.

JOSEPH ERSKINE WELSH (B.A., Biology, Stanford, '71). For the past two years Mr. Welsh has been studying water pollution biology. This included one quarter's research at Hopkins Marine Station investigating current flow patterns from sewage treatment plant outfalls in the Monterey Bay region. He has also conducted detailed investigations into the political problems associated with pollution management. Now a first year medical student at Stanford, Mr. Welsh plans to enter surgical training following graduation. He contributed material in the first part of Chapter VII, discussing water pollution in Monterey Bay.

JOANN AI YUKIMURA (B.A., Psychology, Stanford, '71). Having grown up in some of the remaining natural areas of Hawaii, Ms. Yukimura was naturally interested in environmentally oriented activities at Stanford. A member of the Steering Committee for Stanford's 1970 Earth Day, she plans to continue her studies at the University of California at Los Angeles law school this coming year. Ms. Yukimura contributed the last section of Chapter VII outlining reaction in Monterey Bay to the Bay-Delta Water Quality Control Program.

We wish also to mention our project secretary, LYNDA WEISBERG. She has a B.A. from the University of Chicago in sociology, and has worked as a research assistant on public policymaking and social goals in the Genetics Department. In addition to dispatching the general secretarial duties of the office, she helped with research and bibliographic material for a number of issues.

INTRODUCTION

This is one of three volumes to come from an interdisciplinary study carried out by members of the Stanford University School of Medicine, the Stanford University Department of Communication, the School of Law, and students in the departments of biology, engineering, physics, sociology, and psychology. All research was conducted from summer 1970 through summer 1971, and some three dozen people were involved. Companion volumes present: 1) Media handling of environmental issues; and 2) An annotated "telephone directory" of information sources, for use by press and public, on selected environmental subjects of importance in the Bay Area.

The topics covered in this volume are presented in the detailed table of contents. Environmental reporting is one of the hardest assignments I can imagine a newspaper man carrying out. While some of his old contacts and methods might help him out, the reporter is basically stuck with a technically complex field, having considerable importance to human health and welfare, but usually lacking the flashy news peg, upon which he can base his story. Consequently, the environmental reporter, and his editor, must develop new ways to present this information, both so that they feel it is still appropriate for their newspaper and not a technical journal, and so that their readers will be able to read it with understanding.

Environmental reporting is further complicated by the fact that if you look hard enough nearly everything becomes related to everything else. That, of course, is one of the reasons the field is so interesting. This volume is an attempt to help clarify some of those relationships for the San Francisco Bay Area and its water resources. We have generally reviewed where this region obtains its water, how other water programs, particularly the State Water Project, might affect northern California and San Francisco Bay. Our discussion of the impact San Francisco's waste water disposal plans could have on the Pacific Coast and Monterey Bay led to an evaluation of water problems in that region, including the siting of a nuclear power plant at Davenport. All of these issues have potential impact on human health; and so, they are discussed within the general framework of ecological medicine.

This study was not an effort to mimic Nader's Raiders. We have rather endeavored to present data on admittedly controversial issues as objectively as possible. In most cases draft copies of our manuscripts were critically reviewed by both protagonists and antagonists of the issues at hand. Since complete objectivity is impossible, where bias has entered, we have tried to make this clear, both through our writing style and by explicating our slant. We may not have succeeded completely in this aim.

We believe that the issues presented here have importance and significance both to present Californians and to those generations yet unborn. Therefore we hope that this report can be an aid to both reporter and layman in organizing the complex picture of water input and output in the Bay Area and its relationship to population growth in Los Angeles and agricultural development in the Central Valley.

During preparation of this report many people gave unstintingly of their time and effort. Dr. Joshua Lederberg, Professor and Chairman, Department of Genetics; Dr. John Farquhar, Associate Professor, Department of Medicine; Dr. Rodney Beard, Head, Division of Preventive Medicine, Department of Community and Preventive Medicine; Dr. Mark Perlroth, Assistant Professor of Medicine; (all at the Stanford Medical Center); and Dr. Georg Treichel, Professor of Geography, San Francisco State College all provided helpful comments, criticisms, and ideas during the project's initial planning. Dr. Welton Lee and other faculty members at the Hopkins Marine Station in Pacific Grove carefully reviewed portions of Chapter VII. To these and many other people who shared ideas with us, we extend our heartfelt thanks and appreciation. Any errors in fact or interpretation, however, are not their responsibility. This responsibility is solely ours.

I should also like to extend appreciation to the staff of the Falconer Biology Library, Peggy Craig, Ferne Barr, Claire Shoens, and Margaret Fuhrman, for tracking down difficult references and being their usual, friendly, helpful selves. Ms. Glenna Duistermars and Ms. Stephanie Tramz-Timar both served as project secretary during its early phases and helped get it off to a good start.

This interdisciplinary project between the School of Medicine and the Department of Communication is, to my knowledge, one of the first of its kind in the country, and certainly the first of its kind at Stanford. About 4 months ago a major 5-year interdisciplinary study between the Departments of Medicine and Communication started, investigating the success various information campaigns have modifying risk factors associated with heart disease and hence altering disease rate from this top killer. This merely points out the pertinent point that other scientists see advantage in combining their interests with those of communication specialists. Such continued collaboration can only help make this a more habitable world and awaken the public to ideas whose time we hope has not come too late.

David Peter Sachs,
M.D. Candidate, 1972

School of Medicine
Stanford University
10 September 1971

Chapter One

ECOLOGICAL MEDICINE: AN OVERVIEW

During the first part of the twentieth century the great American physician and surgeon, Harvey Cushing, commented, "A physician is obligated to consider more than a diseased organ, more even than the whole man – he must view the man in his world." Achieving this aim has been arduous for the medical profession, and only now is it beginning to approach such a goal. "Viewing the man in his world," within a framework of promoting human health and happiness is no small order; it requires constant interaction and dialogue between a myriad of disciplines and points of view. Indeed, as our world has become more complex, this has become even more challenging.

At the turn of the century, certain physicians did attempt to view man from a global, environmental perspective. These early conquerors of yellow fever and similar diseases profitably wedded ecology and clinical medicine, through proving and understanding the relationship between mosquito vectors and the disease process (1). Such approaches led rationally to simple practices which could *prevent* the disease from occurring in the first place.

It is perhaps obvious to say that it is better to avoid disease than to attempt to cure thousands of suffering people, who are caught up in a poorly understood disease process. Such was the case in 1900 when Walter Reed, Jesse Lazaer, and other physicians began their pioneering efforts against yellow fever. Treatment of this disease was governed as much by mythology as by science. Once these men had proved that the mosquito, *Aedes aegypti*, transmitted the organism responsible for yellow fever (later shown to be a virus), they proceeded to eliminate potential breeding places near villages, camps, and cities; the urban variety of yellow fever was effectively eliminated.

Comprehensive Health Care

Today Dr. Cushing's admonition takes on even greater meaning, as we increasingly take cognizance of social, psychological, political, and environmental variables which all significantly affect human health and

welfare. These problems have been with us at least since the dawn of industrial society, if not before, but we have now evolved a social consciousness which wants to see them ameliorated.

Such awareness has led many of the newly developing comprehensive health care programs to place high priority on preventive measures. This approach can often *seem* simple, as in the case of improving the nutrition of inner-city residents. Because of deficiencies in the area's schools, the people there never really learn about dietary planning. Educational programs conducted by community residents, who are trained by clinic personnel, can enable people to *plan* better balanced meals. Since inner-city transportation is often no more adequate than the schools, a simple shuttle-bus type transportation system can free residents from the grasp of overcharging local (and chain) supermarkets. They thus gain the ability to shop in areas of the city where higher quality food is available at lower prices (2). Simple, preventive approaches, such as this one, can stop many diseases from occurring.

This example illustrates how new methods for delivering comprehensive medical care are affecting health and the quality of life. Solution of this single problem, however, is not achieved through a simplistic approach, but one that encompasses the traditional fields of internal medicine, education, public health, and transportation planning. Another step takes us from this example to the complex spectrum of urban problems, urban population growth, and dwindling resources.

Ecological Medicine

It is from the perspective provided by Harvey Cushing and what we shall call *ecological medicine* that we have undertaken the research program reported in this volume (3). Some may think that ecological medicine is merely a vacuous term equivalent to public health. Perusal of our report, the disciplines involved, and the ideas discussed should present evidence that this approach is even broader for public health is only one of the areas it encompasses.

Ecology is defined as the mutual interactions of organisms with their physical and biological environment. The environment of a specific biological species, then, includes the amount of solar energy reaching its habitat, the temperature, amount of moisture, geologic structure, meteorologic conditions, and the other plant and animal species present, as well as numerous other factors. Environment might be viewed as setting the stage for a drama of life, while ecology *is* that drama, depicting the constant interaction between the multitude of elements comprising the environment. This interaction creates a wide range of positive and negative feedback loops affecting the organism and its environment. We shall look at some of these briefly as we examine the initial approaches taken by our research group into various questions of water resource utilization. A given species can be affected by environmental changes produced by other organisms or by changes which it induces. Since man is also a part of the ecosystem, although he often loses sight of this fact, he, too, is subject to, and not immune from, the feedback resulting from self-induced environmental change. The urban phenomenon is an excellent example of this, as we shall see.

Consequently, within the context of this discussion, the role of ecological medicine is to delineate the interrelationships between the human environment and human physical and mental health. It would assess

the impact of man's urban and environmental changes on his own well being, fully exploring the multiple feedback loops involved, to develop rational, balanced therapeutic procedures. This approach toward human health problems transcends traditional intellectual boundaries. Within such a conceptual framework it is certainly appropriate to discuss water resource availability and use, for without that simple chemical compound life as we know it would be impossible. Moreover, all manner of clinical problems – from infectious disease, to metabolic abnormalities, to strokes and heart attacks – are related to water resource quality, treatment, and supply.

One of the basic points which we shall discuss is allocation of finite resources in the face of expanding populations. This idea is pertinent whether we are discussing only the State of California, the United States, or the world. Generally speaking, overpopulation exists when the biological community requires resources which the environment cannot provide (4). Viewed in this perspective, most urban regions in the United States are as overpopulated as underdeveloped countries throughout the world. It is unnecessary for environmental limitations to originate from natural or food resource shortages alone. They can also arise from the inability of our urban environment to provide adequate housing, sanitation, transportation, educational and medical services, and similar cultural resources. These limitations can have just as great an impact on the inhabitants there as food, fossil fuel, or other mineral resource shortages.

Urbanization and Health

A barrage of factors impinge upon the urban dweller, all with potential health impact. Some are obvious, such as the simple fact that disease-carrying bacteria can spread with greater ease in a more crowded area. The city provides such a nexus. Bacteria responsible for typhoid fever, cholera, amoebic dysentery all can strike more potential victims in an area with a highly concentrated population and poor waste water and drinking water facilities. Public health specialists, working with engineers, chemists, and biologists, developed both the theoretical framework and the practical procedures for preventing these diseases. Once their bacterial origin had been established *and* accepted, about one hundred years ago, it was possible to design an empirically-based sanitation system that would prevent these water-borne diseases from taking hold. On the whole, medicine, public health, and engineering have done rather well in coping with this type of environmental health hazard.

Pollution Health Hazards

There are, though, many other phenomena which can affect the mental and physical health of the urban dweller. These frequently are the result of "residuals" from a manufacturing, biological, or energy conversion process. A residual is simply a quantity of material which is unused in a production process, whether that be photosynthesis or steel manufacturing. A residual is waste; but it has the potential for reuse. Schematically, we could think of pollution creation as follows:

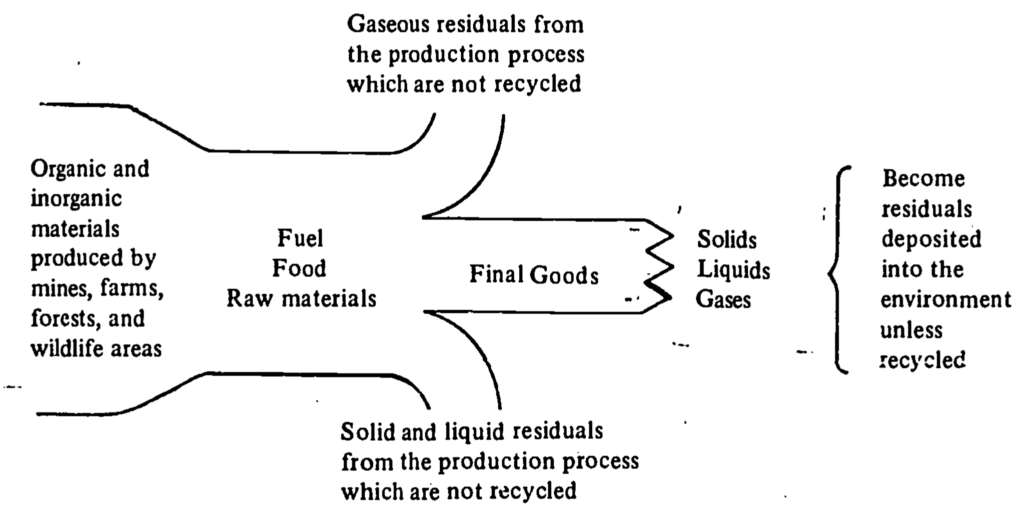

Figure 1-1 (5)
Schematic of the goods-residuals production process

Air Pollution, Solar Radiation, and Albedo

Earlier in this chapter we mentioned the idea that man's urban activities generate feedback which affects both himself and other organisms in the environment. We can perhaps gain better insight into this through an example. The amount of solar energy available at our planet's surface is obviously of vital importance: not only is it from this source that all life derives its energy, but it is crucial for maintaining planetary climatic and water balance. Alteration in any of these factors would have cascading effects on living populations and might well directly influence human disease rates.

A certain percentage of incident solar radiation is reflected at the earth's atmosphere by planetary albedo. Albedo can be visually thought of as a thin shell of small particles, around one micron or less in diameter, encircling the planet. Clouds, for example, form part of the albedo and are responsible for reflecting solar energy away from earth. Their presence has been relatively constant throughout time. We are more concerned with additional factors which could increase albedo, since such changes would indeed lower the energy available for photosynthesis and could alter climatic conditions. Have residuals from human activity, released into the air, altered the earth's albedo?

Initial efforts to shed light on this question examined conditions following in the aftermath of major volcanic explosions, such as Krakatoa, in 1883, and Katmai, in 1912. Generally speaking atmospheric turbidity increased following such cataclysms, as billions of small, sub-micron particles were shot into the upper atmosphere. Turbidity and albedo returned to normal after approximately three years, depending on the explosion's severity (6). This caused planetary albedo to increase. Most people were aware of this only because of the flaming red sunsets which followed the Krakatoa explosion for about one year. They probably did not realize that other changes occurred during the period after these explosions. Over widely separated areas of the globe, populations of certain insect and mammalian species dropped. Influenza outbreaks in England and Wales sharply increased. Even after other factors which could have caused such fluctuations were accounted for, these biological changes retained validity and statistical significance (7). Such volcanic explosions may also explain large-scale temperature changes during those periods, accounting

for a drop of as much as 0.5°F. (8,9,10) Because this refers to a drop in *mean* annual, global temperature, it is highly significant.

The *effects* of decreased solar radiation at the earth's surface discussed above are the result of acute, specific events — volcanic eruptions. But what of the long-term changes? From 1930 to 1960 dustfall in high mountain regions of the U.S.S.R., well away from local pollution sources, increased 20 times. The concentration of sub-micron particles in the upper atmosphere over both rural and urban United States has increased, on the average, by a factor of 10 during the past 10 years (11). Moreover, following the volcanic eruption of Mount Agung in the East Indies in March of 1963, the global turbidity in the upper atmosphere had not returned to normal *5 years later*. This has caused some consternation among professional circles, since the increased turbidity which followed Krakatoa, a much more violent explosion, lasted only 3 years. Not surprisingly, there seems to be considerable data to support the contention that what we are witnessing is superimposition of this explosion over a longer-term trend toward increasing turbidity and albedo caused by man-made air pollution (12). Indeed, careful analysis of the data collected both preceding and following the Mount Agung explosion reveals a general, global turbidity increase of about 80 percent per decade since 1950. The overall increase per decade since the start of the twentieth century, however, has only been about 20 percent (13). This evidence confirms a sharp rise in albedo during the past several decades.

An analysis of world temperature data shows that the average global temperature, from the mid-nineteenth century until about 1940, *increased* by 0.7°F. Since 1940, though, the mean world temperature has *decreased* by 0.2°F (14). As would be expected, there are several schools of thought which attempt to account for these observations. Carbon dioxide increases in the atmosphere from the burning of fossil fuels have been thought responsible for the temperature rise until 1940. Changes in the amount of energy leaving the sun do not seem to account for the temperature drop since that time (15). Since residual sub-micron particles have been increasing gradually since the turn of the century and much more rapidly since about 1950, it is appealing to postulate that the increase in albedo, with resultant drop in absorbed solar radiation, is a major factor behind this temperature decrease. If this hypothesis proves correct, then one man-made factor — burning fossil fuels — would account for a temperature increase, while increasing albedo from particulate air pollution has been reversing that phenomenon. In any case, a man-made geophysical experiment of such magnitude should well concern us and warrants careful documentation (16).

The purpose of the above discussion has been to point out that residuals from the production process which are discharged into the air and not recycled might have feedback effects on man above and beyond the direct toxicologic consequences. Professionals generally agree that certain chemicals released into the air can also aggravate existing pulmonary and cardiac diseases, particularly in elderly or debilitated people (17,18). Sulfur oxides, nitrogen oxides, and ozone, all common components of urban air pollution, can destroy most of the body's normal defense mechanisms against air-borne invaders. Hence, rates of influenza and pneumonia often increase with severe air pollution levels. Evidence is accumulating which indicates that these same compounds may actually destroy portions of the lung, making it more difficult for oxygen to

enter the bloodstream. Specific diseases, such as emphysema, bronchitis, bronchiectasis, and bronchial asthma are all thought to be worsened by urban air pollution (19).

Production residuals, or pollution, which enter *any* of the major environmental components – air, land, or water – can have multiple feedback effects on human society and health. Pollution problems are not alone in this regard; there are many other types of urban phenomena which can exert similar influences, both advantageous and deleterious, which we shall not have time to discuss in this brief volume.

Water and Human Settlements

Before an urban area, or any concentration of people, can even produce enough pollution to cause concern they must have a sufficient water supply. Such a resource is necessary not only for industrial production but agricultural production (i.e., supplying the energy resources necessary for people) and direct human consumption. Air resources tend to be fairly homogeneously distributed over the earth. There are variations, of course – regions at a higher altitude have less oxygen than those at sea level. To be sure, man-made "additives" also vary in concentration from locale to locale, from city to city. The point is, though, that air is virtually continuously distributed over the earth's surface. No city planner has ever had to concern himself with trying to get more air into a geographical area so that the growing population there will have enough to live on, so that crops feeding them will also have sufficient supplies, and so that industrial operations will have adequate resources for their needs.

This is not the case with water resources. People frequently settle in regions where water reserves are inadequate to support a population larger than the original one. The Los Angeles area is an excellent example of just such a settlement. Early settlers obtained most of the water they needed through ground water sources, i.e., wells. There was plenty of water stored in this way to supply a limited population with a limited agriculture. Because of its dry, warm climate, however, it continued to be attractive to other settlers and farmers; and what in the late 1700's and early 1800's had been a little village continued to grow. The existing ground water reserves were becoming inadequate, so the City of Los Angeles had to look to other parts of the State and the West to supply its burgeoning needs. This is the story we chronicle in the next chapter.

Our point here, though, is that without such water resources, production residuals, which can have both direct and indirect human health effects, could not even be produced. Air or water pollution would not be problems to worry about, if there were not sufficient water reserves to drive the production machinery necessary for such waste production. Furthermore, without water resources it would be impossible for cities to reach massive proportions with the accompanying social and psychological difficulties which affect human health. Viewing the man in his world within the framework of ecological medicine must include a study of water resources.

Urbanization and Water

California provides a unique history for such a study. It has extensive fresh water resources, but they

are located primarily in the northern part of the state, away from the present urban concentrations of San Francisco and Los Angeles. In the years following the Gold Rush, as it grew rapidly, San Francisco was able to meet its water needs from ground water reserves and other local sources. As was the case with Los Angeles, by the end of the nineteenth century San Francisco also had to look elsewhere for water. Both of these quests were to develop into extensive aqueductal undertakings involving massive rearrangements of the State's fresh water reserves.

Moving water from one place to another changes the environmental conditions in both regions, affecting all biological levels from the simplest algae to vertebrates, including man. In the chapters which follow we shall explore some of the changes which these water projects have brought to forms of life lower down on the evolutionary tree than man. Such study is necessary before we can fully appreciate the impact on people and on human societies.

Earlier we mentioned the public health effects which improper waste-water management can have. New medical evidence seems to indicate that other characteristics, besides its bacterial and viral sterility, can have adverse effects on health and life. Early studies reviewing the work of the Japanese investigator, J. Kobayashi, showed that people whose water supply came from a *soft* water source, as opposed to a ***hard*** water source had higher death rates from both heart disease and cerebral hemorrhage (strokes) (20). More recent evidence shows that soft water drinkers have a higher sudden death rate from heart attacks as well (21). Different studies also link other vascular diseases, such as hypertension (high blood pressure), with soft water (22). The exact mechanism underlying these adverse health effects from soft water is not yet completely understood, but it is probably related to the concentration of trace metals in the water, such as cadmium, chromium, and lithium (23,24). The importance of such information to water planners is especially significant when we realize that water conveyed through aqueductal systems is soft, while well water is hard. The objectives driving the municipal and state water planners 75 to 100 years ago certainly could not have taken account of such findings. They were more concerned with water delivery alone, and their actions have had far-ranging consequences for the State of California.

FOOTNOTES

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3. David Peter Sachs, "Toward a Comprehensive Program of Ecological Medicine," *The Pharos* of Alpha Omega Alpha, Vol. 34, No. 4 (October 1971), in press.

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5. Robert V. Ayres, and Allen V. Kneese, "Pollution and Environmental Quality," in Harvey S. Perloff, *The Quality of the Urban Environment* (Washington, D.C.: Resources for the Future/Johns Hopkins Press, 1969), p. 36.

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7. Kenneth E. F. Watt, "Man and the Environment," in *Conferences for the Developing Professional* (Washington, D.C.: The Institute for the Study of Health and Society, 1969), pp. 50-55.

8. James T. Peterson and Reid A. Bryson, *Op. Cit.*, pp. 120-121.

9. Robert A. McCormick and John H. Ludwig, "Climate Modification by Atmospheric Aerosols," *Science*, Vol. 156, No. 3780 (9 June 1967), pp. 1358-1359.

10. J. Murray Mitchell, Jr., "Recent Secular Changes of Global Temperature," *Ann. New York Acad. of Sci.*, Vol. 95, Art. 1 (October 5, 1961), p. 246.

11. James T. Peterson and Reid A. Bryson, *Op. Cit.*, pp. 120-121.

12. *Ibid.*

13. Robert A. McCormick and John H. Ludwig, *Op. Cit.*, p. 1359.

14. J. Murray Mitchell, Jr., *Op. Cit.*, p. 248.

15. Kenneth E. F. Watt, *Op. Cit.*, p. 52.

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17. For more detailed discussions of such disease pathogenesis, see M. M. Wintrobe, M.D., *et. al.* (Eds.), *Harrison's Textbook of Internal Medicine* Sixth Edition (New York: McGraw-Hill Book Company, 1970), pp. 1322-1332.

18. For what is perhaps one of the most graphic descriptions of medical problems produced by a smog disaster see Berton Roueche, "The Fog," in *Eleven Blue Men* (New York: Berkeley Medallion Paperbacks, 1953), pp. 194-215. This chapter reads like a novel but is medically accurate. It helps place statistics in very human terms.

19. M. M. Wintrobe, M.D., *et. al.* (Eds.), *Op. Cit.*, pp. 1331, 1332.

20. Naomi F. Goldsmith and John R. Goldsmith, "Epidemiological Aspects of Magnesium and Calcium Metabolism," *Arch. Env. Health*, Vol. 12, No. 5 (May 1966), p. 609.

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22. Subcommittee on Environmental Improvement, Committee on Chemistry and Public Affairs, American Chemical Society, *Cleaning Our Environment: The Chemical Basis For Action* (Washington, D.C.: American Chemical Society, 1969), pp. 146-152.

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Chapter Two

WATER DEVELOPMENT IN CALIFORNIA:

A POLITICAL HISTORY OF THE CALIFORNIA STATE WATER PROJECT

Insuring the availability of fresh water supplies requires the expenditure of other resources both human and natural. How much water will be available to a given area and how this water will be supplied is determined by decisions based upon scientific knowledge, technological know-how, reason, politics, and pure whimsy. This study attempts to examine all of these factors as they have been present in various decisions concerning water supply and development in California; and particularly, it is the story of the engineering plan known as the California State Water Project.

In 1959 and 1960 the State Legislature and the voters of California decided that development of the State's water resources was desirable, and committed the State's financial resources to providing that development. These decisions are important because they purport to be binding upon three generations of Californians. However, to focus on these decisions as isolated events would be myopic. What the decisions really represent are statements that at those points in time and based upon available information a majority considered a vote for the State Water Project to be in their best interests.

This Chapter will 1) sketch the historical and political antecedents of the California Water Resources Development Bond Act (Burns-Porter Act) votes; 2) analyze the private interests which entered into the decisions; 3) examine the information upon which the decisions were based; 4) recount development since 1959; and 5) discuss the State Water Project in its present political context.

I. Water Resources

California is a semi-arid state with a population-water supply imbalance. About 90% of the people live south of the Sacramento Basin, while 75% of the fresh water runoff occurs north of that area. In some areas of the state, rainfall exceeds 100 inches per year (1). The mean annual precipitation is about 22.7 inches,

however, and most of the area below the Tehachapi Mountains has an average annual precipitation of less than 10 inches (2). This uneven distribution of precipitation over the state gives rise to a similar uneven distribution of usable surface water in the state. Califomia receives gross annual precipitation of about 190,000,000 acre-feet (AF) of water per year (3). (An acre-foot is the amount of water necessary to cover one acre of land – roughly one football field – to a depth of one foot.) Of this amount, about 71 million AF per year (MAFY) become natural stream run-off, which is distributed approximately as follows: (See Figure 2-1)

North Coast and Sacramento Basin	67.6% of total
Central Valley	15.5% of total
S.F. Bay, Central & South Coast Area	10.5% of total
Lahonton and Colorado Deserts	6.4% of total

There are also wide variations in annual precipitation. The mean annual precipitation for the years 1897 to 1955 varied in individual years from 36.88 to 11.56 inches. Regional variations are even wider. In addition to the yearly variation, there appear to be wet and dry cycles consisting of about 14.5 dry years and about 12.5 wet years, building an average cycle of 27 years (4).

The surface water supply is supplemented by an underground accumulation estimated at over one billion AF, with about 125 million AF of usable water available before any overdrafts were made. The safe annual yield – the amount which may be withdrawn without depleting the underground reserves – is about 5 MAFY (5).

Another major source of water for California is the Colorado River, which contributes more than 5 MAF annually to Southern California users (6).

Reclaimed and desalinated water are as yet small, but potentially significant sources of water for the future (7).

II. Water Use

Total use of controlled water in the state is put at about 36 MAFY (8) about 60% of which is surface water while the other 40% is pumped from the earth (9). It is estimated that approximately 86% of the controlled water used in the state goes to agricultural uses. The remaining 14% goes to urban and miscellaneous uses (10). It is important to note the large percentage of water which goes now and which will continue to go to agricultural uses.

The areas of the state which have developed the greatest needs for water have been those with the least available usable surface water. About 75% of the surface runoff occurs north of the Sacramento-San Joaquin Delta, while about 75% of the water demand occurs south of the Delta (11). This imbalance between supply and demand which is, in part, a function of population size has led the inhabitants of deficient areas to expend ever-increasing amounts of resources to obtain adequate water supplies.

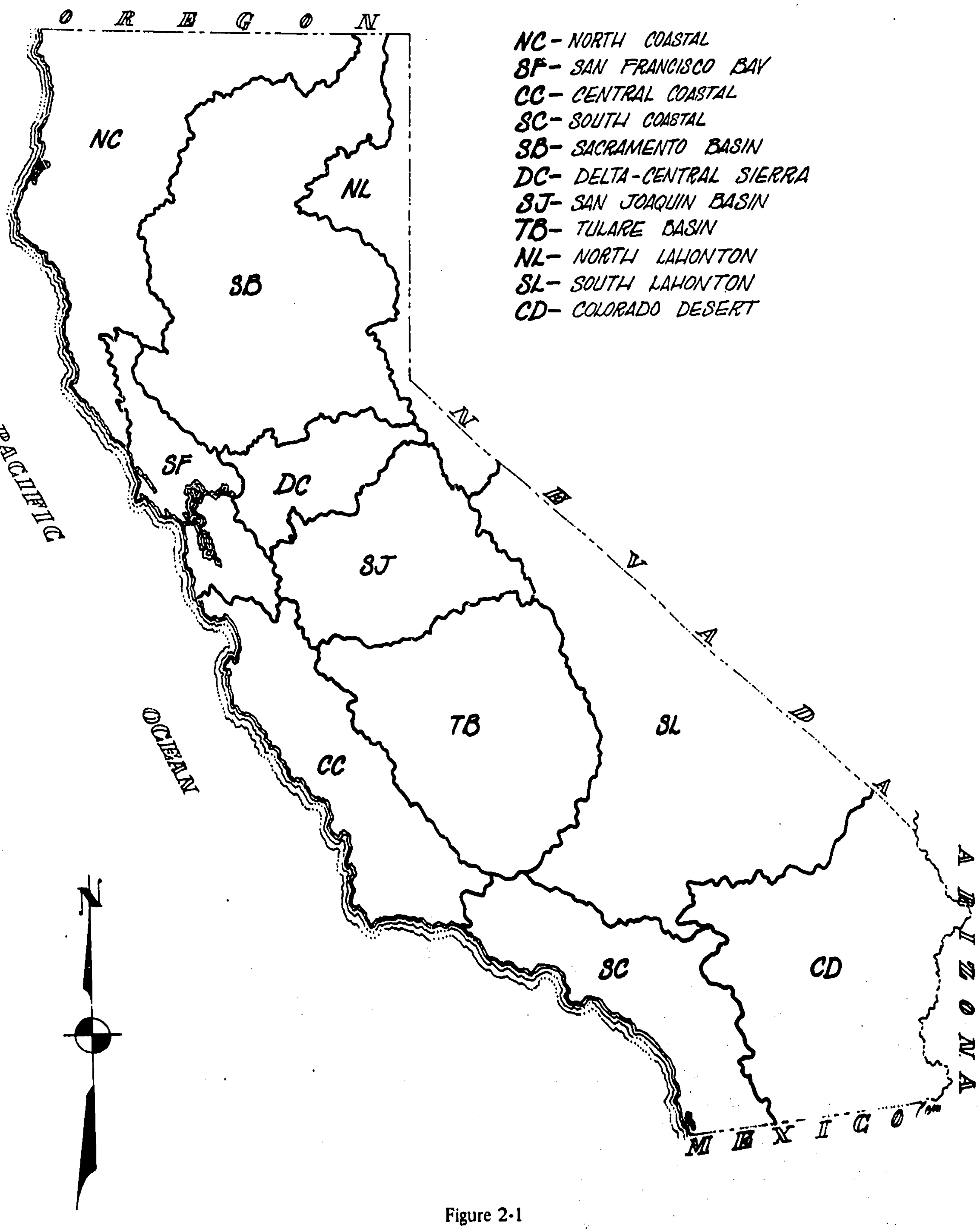


Figure 2-1

HYDROLOGIC STUDY AREAS
OF CALIFORNIA

STATE OF CALIFORNIA, THE RESOURCES AGENCY, DEPARTMENT OF WATER RESOURCES
ADAPTED FROM BULLETIN NO. 160-70

III. History of Water Development in California

A. 1773-1900

The Spanish missionaries engineered what seems to have been the first water development projects in California. The Old Mission Dam begun in 1773 at San Diego was the first such development (12).

The Gold Rush in 1849 sparked the first major period of population growth in California. The people brought to California by the Gold Rush began to form concentrations of population in northern California and created impetus for increased agricultural activity, both of which created increased demand for water. California gained its statehood in 1850, and in 1865 the State Legislature appropriated money to study a canal on the west side of the Sacramento Valley (13). Between 1865 and the turn of the century, state and federal hydrological studies were made, and deep-well pumping was introduced. The population and economy of southern California began to grow rapidly, supported by underground water reserves. In 1887, the Legislature passed the Wright Act, making it possible for irrigation districts to condemn land and issue bonds for the purpose of building irrigation projects. The face of California began to change.

During this time, water was viewed as an often unavailable, but basically inexhaustible resource. There was plenty of water – it had only to be brought from where it existed to where it was needed. Planning tended to be short-range and development of water projects tended to be localized geographically (14). This attitude continued to some extent into the early years of the twentieth century, but the demand for water was forcing a change in outlook. Water supply was becoming an expensive business, requiring a large bankroll and careful planning.

B. 1900-1935

In 1902, Congress passed the first Reclamation Act to encourage the development of agriculture in the west (15). Through the activities of the Bureau of Reclamation, the federal government made available inexpensive water supplies and reclaimed marshlands for agricultural use. In 1905, Los Angeles voters approved bonds for the Owens River aqueduct. (See Figure 2-2) That same year, Pacific Gas and Electric Co. was incorporated and began building a series of dams to develop hydroelectric power. The Owens Valley-Los Angeles aqueduct was completed in 1913, the same year San Francisco persuaded Congress to authorize Hetch Hetchy Reservoir inside Yosemite National Park (16).

The Owens Valley and Hetch Hetchy projects were significant in two important respects. First, they represented the use by urban population centers of accumulated hydrological and geographic knowledge, engineering expertise and long-range planning and public financing to transport water long distances. Second, they together contained most elements of the political battles over water that have been waged in recent years, as the growth of populated areas with all their needs assured a conflict with less populated areas.


MAJOR FEATURES OF THE
STATE WATER PROJECT
CENTRAL VALLEY PROJECT
AND
SELECTED MUNICIPAL AQUEDUCTS
LEGEND
STATE WATER PROJECT
CENTRAL VALLEY PROJECT (FED. BUR. OF RECLAMATION)
JOINT USE FACILITIES
MUNICIPLE AQUEDUCTS
MAJOR RIVERS
OREGON
NEVADA
ARIZONA
MEXICO
PACIFIC OCEAN
CLAIR ENGLE LAKE
SHASTA LAKE
EUREKA
WHISKEYTOWN RES.
REDDING
CORNING CANAL
LAKE OROVILLE
TEHAMA COLUSA CANAL
MARYSVILLE RES.
AUBURN RES.
FOLSOM LAKE
MOKELUMNE AQUEDUCT
NORTH BAY AQUEDUCT
SACRAMENTO
FOLSOM-SOUTH CANAL
PADRE RES.
CAMANCHE RES.
SAN FRANCISCO
PERIPHERAL CANAL
NEW MELONES RES.
HETCH-HETCHY RES.
CRYSTAL SPRINGS LAKE
LAKE DEL VALLE
HETCH-HETCHY AQUEDUCT
SOUTH BAY AQUEDUCT
SANTA CLARA CANAL
DELTA MENDOTA CANAL
MADERA CANAL
SAN LUIS RES.
LAKE CROWLEY
HOLLISTER WATSONVILLE CONDUIT
MILLERTON LAKE
FRESNO
TINEMAHA RES.
PLEASANT VALLEY CANAL
FRIANT KERN CANAL
LOS ANGELES AQUEDUCT
CALIFORNIA AQUEDUCT
HAIWEE RES.
COASTAL BRANCH
SAN LUIS OBISPO
BAKERSFIELD
BOUQUET RES.
PYRAMID LAKE
CASTAIC LAKE
LOWER SAN FERNANDO RES
SILVERWOOD LAKE
LOS ANGELES
COLORADO RIVER AQUEDUCT
LAKE MATHEWS
LAKE PERRIS
SAN DIEGO AQUEDUCT
SAN VICENTE RES.
LOWER OTAY RES.
SAN DIEGO
N
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
ADAPTED FROM BULLETIN NO. 160-70

Figure 2-2

1. **Owens River Conflict**

Los Angeles officials made their decision to acquire supplemental water supplies from the Owens River sometime in 1904. After quietly beginning acquisition of certain strategic land in the Owens Valley, Los Angeles persuaded Congress to drop plans for a Federal Reclamation project. In 1905, Los Angeles voters approved bonds to build an aqueduct, and construction was begun. Unfortunately, no one bothered to consult the inhabitants of the Owens Valley on this grand undertaking. The local citizens watched in frustrated horror as Los Angeles bought up first key lands and water rights, then, finally, most of the valley, destroying the agricultural economy. Eventually, a tourist trade replaced the lost agriculture, but the conflict left scars that have not healed to this day. Erwin Cooper has called the episode a "case of aggravated condemnation (17)." More than the effect on the people of Owens Valley, Los Angeles' imperious approach to filling its water needs gave not only Los Angeles, but all of southern California, the image of a heartless monster riding roughshod over everything in its path in a greedy quest for water. This image remained very much alive in 1959 and 1960 when California fought its major water battles, and the image remains to a lesser extent today. The Owens Valley controversy sparked legislative battles over the expansion of powers of condemnation, which was generally supported by urban areas and opposed by rural areas.

2. **Hetch Hetchy Conflict**

Hetch Hetchy was a different type of conflict. Here, there were no issues of displacing inhabitants of an area by taking their water and destroying their economy. Rather, the issue was the destruction of a beautiful natural area in a national park. Coming right on the heels of Theodore Roosevelt's conservation crusade, the battle waxed hot between conservationists who wanted to preserve the valley in its natural state, and San Franciscans who wanted to provide their city with a reliable water supply. But there were plenty of beautiful valleys, the argument went, and San Francisco needed the water, so Hetch Hetchy was built.

During the second two decades of the 1900's, as the need for water put greater pressure on the existing usable supply, the idea of water as an inexhaustible resource gave way to the idea of water as a resource which needed conserving. In 1916, the Legislature sponsored a "Conference on State Water Problems." This conference was followed in 1921 by an authorization for a comprehensive statewide water resources investigation. These investigations extended over the years from 1921 to 1929, with the results published from time to time in twelve bulletins of the State Division of Water Resources (18). The principle of conservation began to be expressed in various legislative acts such as the "Water Conservation Act of 1927," and the "Water Conservation Act of 1929 (19)." The basic idea which developed during this time was to impound water which was "wasting" to the sea, and conserve it behind man-made dams, for controlled distribution to human uses through systems of aqueducts and ditches (20). This philosophy of water management has dominated the thinking of decision-makers to this day.

The culmination of the investigations authorized in 1921 by the Legislature was Bulletin 25 of the State Division of Water Resources, published in 1930 and submitted to the Legislature in 1931 as the

"State Water Plan." *Bulletin 25* called for the full development of the Central Valley's surface waters, primarily for irrigation, at a cost of about $158,000,000. After over a year of studying the proposal, the Legislature submitted a referendum to the voters for a $170,000,000 bond issue to finance the "Central Valley Project" and the voters approved the sale of the bonds (21).

C. 1935, Central Valley Project

Due to the depression which hit America in the thirties, California's Central Valley Project bonds were not sold. The State then tried to get a loan from the federal government to build the project. When this loan was rejected, the State acquiesced in a federal take-over of the project. In 1935, President Roosevelt approved the Bureau of Reclamation's feasibility report for building and managing the huge Central Valley Project (22).

Central Valley Project water was first delivered to San Joaquin Valley farmers in 1944. This event was welcomed by most farmers – but with mixed emotions. For along with federal water went federal regulation, including a provision in the reclamation laws known as the excess land law, which limits each landowner to enough water to irrigate 160 acres of land (23). The 160-acre limitation can be circumvented by various means and has never been stringently enforced (24), but its very existence made the predominantly large Central Valley agricultural interests supremely unhappy. These interests did not see the federal law as a measure to prevent federal subsidy through cheap water which would unjustly enrich large landowners, but as an invidious and even "Communist-inspired work (25)."

Agriculture is even today California's number one industry, and in the 1940's and early 1950's the dominant power – both economic and political – was in the hands of large agricultural interests. Cooper points out that the large agricultural and large business interests in the state were the same at this time (26). Many of these people never gave up the notion that the Central Valley Project was basically a State project taken over by the federal government during hard times (27). Thus, once the economic outlook began to brighten in California in the 1940's, Central Valley and business interests began to assert their power to escape from the 160-acre limitation by having the state take over control of the Central Valley Project. Plans to have the Bureau give the Project back to California and to buy the Project back from the federal government were supported by the State Chamber of Commerce, Farm Bureau, and Irrigation Districts, and championed by State Engineer A. D. Edmonston, but proved unworkable (28). An end run around the 160-acre limit was tried by having the Corps of Engineers, which before 1944 was not subject to the 160-acre provision, build "flood control projects" and then deliver the water to the farmers (29). The Corps would not be co-opted and this scheme also proved unsuccessful. Congress plugged the loophole in 1944 by making the Reclamation laws applicable to irrigation water developed by Corps of Engineers' projects, subject to the acreage limitation (30). But the movement to have California control her own water destiny was strong and continued on many fronts.

In 1948, the Legislature passed the Water Resources Act, putting the State in the role of planning and managing water resources statewide (31). The planning function was put in the hands of a newly-created

State Water Resources Board. In 1947, the Legislature directed the State Water Resources Board to inventory the water resources and needs of the State 32). The results of these investigations were published in bulletins released in 1951, 1955 and 1957 (33).

A special report on a portion of these investigations was financed by the California Central Flood Control Association. The State Engineer, A. D. Edmonston, analyzed flood control on the Feather River, and went on to describe the possibilities for using the harnessed water of the Feather River. This work might have been prosaic. But Edmonston had a dream to see the state take over water development in California and he spelled out his dream in this flood control report. His report, released in 1951, was called *Report on Feasibility of Feather River Project and Sacramento-San Joaquin Delta Diversion Projects Proposed as Features of the California Water Plan.*

D. Feather River Project

Edmonston's report had special significance, because the Feather River Project had become the latest vehicle by which the State of California was to escape from the clutches of the Bureau of Reclamation (34). State planning was important, because the Bureau was at the same time surveying the possibilities for further developing the Northern California waters for irrigation and delivery to Southern California (35). The Legislature authorized the project in 1951, without appropriating money for construction (36). In 1955, Edmonston issued a follow-up report entitled *Program for Financing and Constructing the Feather River Project as the Initial Unit of the California Water Plan* (37). The Legislature selected the Bechtel Corporation to analyze Edmonston's findings. Bechtel reported back that the engineering was sound, but that:

> The Feather River Project ... [is] not financially feasible on the basis of revenue derived from water charges and the sale of electric power at the rates assumed in the report unless the federal and state governments contribute to the cost of the project funds in substantial amounts on the basis of statewide concern (38).

The Legislature then reauthorized the project (39).

From the time Edmonston's first report appeared in 1951 until 1959, the legislature moved slowly on the Feather River Project. During this time approximately 100 million dollars was appropriated for studies, right-of-way acquisition, and railway and highway relocation (40). However, the legislature could not pass an act which would provide funding for the project because northern and southern representatives were deadlocked over what guarantees a project enabling act should contain for each area.

In 1956, the State Water Resources Board passed into history as the legislature enacted statutes creating the State Department of Water Resources, along with the California Water Commission and the Water Rights Board (41). Harvey O. Banks became the first director of the Department of Water Resources. In 1957, *Bulletin No. 3* was published with the recommendation that the California Water Plan outlined in *Bulletin No. 3.*, including the Feather River Project, be adopted as the general plan for water development

in California. The legislature did not act on the recommendations, but instead called for reviews and explanations of the proposed California Water Plan (42). The north-south deadlock over the Feather River Project could not be broken.

E. Burns-Porter Act.

1. Drafting and Strategy.

Governor Edmund G. Brown came into office with a vow to break that deadlock. He had taken an interest in California's water dilemma while he was State Attorney General, working with and learning from a State attorney named B. Abbott Goldberg (now a Superior Court judge in Sacramento County). During his campaign for Governor, Brown promised that the Feather River Project would be implemented (43). So important to Brown was the implementation of the Feather River Project that he virtually staked his political life on its success.

Governor Brown made Ralph Brody, an attorney, Deputy Director of the Department of Water Resources and Special Counsel to the Governor on Water Matters, and put him to work rewriting the stymied project enabling act and formulating the strategy for getting it through the legislature.

The Governor's office additionally asked Harvey Banks, as head of the Department of Water Resources, to design a feasible project that would meet water demands within a reasonable point in time. Mr. Banks and his Department responded with a project that would take care of projected water needs through 1985 or 1990 (44), at a cost estimated at $3 billion with inflation, or $2.25 billion if inflation were not taken into account (45). These figures included funds already expended (46). They felt that this was a reasonable planning period which would meet crucial water needs and yet allow enough flexibility for adjusting to changed conditions and technological developments in water supply to meet needs after 1985 or 1990. The Governor felt that the public would not pass a bond issue of over $2 billion, so Ralph Brody designed a financing package of $1.75 billion in general obligation bonds, and $500 million composed of funds already expended and miscellaneous revenue mostly from tidelands oil funds, for a total of $2.25 billion (47). The Governor and his planners considered inflation an insignificant and speculative problem. Financing for the project would be tight, but if everything went according to plan the miscellaneous revenues would make up the difference.

Financing of the project had been a major stumbling block in past legislatures. The north did not want to pay for the south's water, and wanted guarantees that the south would not get all of the north's water as Los Angeles had gotten all of the Owens Valley water. The south was not willing to pay for water unless there were guarantees that the water would be delivered. To both sides this meant constitutional guarantees (48). Additionally, there was a state constitutional limit on the amount of general obligation bonds which could be issued by the legislature without approval of the electorate (49). The natural solution to all of these problems had been thought to be a constitutional amendment. However, the two-thirds legislative vote required to submit a constitutional amendment to the people made any such amendment impossible. Ralph Brody sidestepped this hurdle by utilizing a constitutional provision which allowed the

legislature by majority vote to submit bond proposals in excess of $300,000 to the electorate, which could then pass the bonds by a majority (50).

To help allay the fears of the northerners, the act specifically made applicable the area of origin and county of origin laws which guaranteed such areas first rights to all waters originating within their borders. If the legislature amended those laws, they would apply as amended (51).

For the southerners certain works were specified that would guarantee a firm water supply (52), and the legislature was proscribed from tampering with the provisions of contracts between the Department of Water Resources and the buyers of water (53). The water bond act written by Ralph Brody truly contained something for everybody, an attribute which caused opponents to label the act "pork barrel" and "a grab bag (54)." Brody and the other people who had worked on the water bond act knew that it was not perfect, but believed it to be the best plan obtainable given the necessity for compromise. However, they were not relying on the merits of the act alone to bring it through the Senate and Assembly.

Governor Brown knew that neither the provisions of the bill by itself nor the "honeymoon period" traditional for new governors would bring the bill through. Nothing could be left to chance, or the water project would be killed for another year (55). So, to champion the act in the legislature, the Governor chose Senator Hugh Burns of Fresno and Assemblyman Carley Porter of Compton. These men together represented the two groups who would benefit principally from the act – the San Joaquin farmer and the southern California city dweller. In addition, they had seniority, prestige and were masters at the art of legislative politics. While they had negligible roles in drafting the act which now bears their names, they were instrumental in winning its passage.

Allied against Governor Brown's forces were representatives from the areas of origin, and a contingent of legislators from the southland who joined in the Metropolitan Water District's opposition of the Feather River Project. The Senate was weighted in favor of the north and areas of origin, while the Assembly was weighted in favor of the water short areas in north and south (56). Thus, the proponents of the measure were confident that they could win Assembly passage if they could only get the bill through the Senate.

2. Issues

There were almost as many issues surrounding the Burn-Porter (B-P) Act as there were legislators. Proponents cited a desperate need for water in the San Joaquin Valley and southern California, and foretold of economic disaster if the project were not built (57). They cited increasing overdrafts on the ground water supply and the resulting shortage of water, land subsidence, and salt water intrusion into the ground water supply (58). They pointed out that California could lose over a million acre-feet of water annually to Arizona as a result of the *Arizona v. California* lawsuit then pending before the Supreme Court (59). And beside the economic benefits to central and southern California, the project would avert a projected water crisis in San Diego and provide flood control benefits for northern California, as well as the economic benefits that the construction of project units would bring locally.

Opposition to the measure centered around lack of guaranteed water rights and the huge price tag of

the project. Representatives from water-rich areas were afraid that once their water began going south it would be lost forever, despite the area and county of origin laws (60). Former Assemblyman Lloyd Lowrey, in a letter to the author, wrote "Water once put to use in a foreign environment, from a practical and political viewpoint will not be withdrawn. Once transported, water is lost to the local area (61)." Much the same sentiment was expressed by Los Angeles Mayor Norris Poulson, who is quoted in the Los Angeles *Times*, of June 18, 1959, as saying,

> I cannot see how any future State legislature could possibly alter the formula of the new water bill after its 50 year term expires. Southern California will always be the population center of the state and the majority of lawmakers and voters alike would not and could not make changes damaging to this area (62).

Furthermore, the price of water would be based upon a "Delta Pool" charge, computed from the costs for works in and north of the Delta, with any transportation costs added on. The Delta charge would be paid by users upstream from the Delta as well as users in and downstream from the Delta, and upstream users thought it ridiculous to pay for water they would normally use for nothing. This pricing mechanism prompted Assemblyman Pauline Davis to say that such a method made the area of origin laws meaningless (63).

Representatives from water-scarce areas claimed that the Burns-Porter Act guaranteed no water rights to any water buyers, that the county and area of origin laws made other rights meaningless. The Metropolitan Water District, led by its chairman Joe Jensen, was opposed to any plan which did not provide ironclad guarantees to the south (64). Time was on their side; the economic and political power was shifting from the rural north to the heavily populated south, and in a few more years the south could get whatever it wanted without having to make any compromises for the benefit of anybody else. Several legislators identified closely with this position and opposed the Burns-Porter Act to the end (65).

Financing of the Feather River Project was another hunting ground for its opponents. The wisdom of building such a huge project seemed questionable when technological advances promised to make water available at less cost by the time the State Water Project was in full operation. Assemblyman Clark Bradley opposed building any conveyance works over the Tehachipis, on the grounds that waste water reclamation could handle the needs of urban southern California more cheaply (66). Furthermore, the project appeared to be under-financed, which meant that the $1.75 billion would not be adequate to complete construction of the system. Opponents contended that more money would be needed later either from more general obligation bonds or some other source. In the meantime, voters would be deceived into thinking that the $1.75 billion was full payment, and not just a down payment, on the Feather River Project.

The Governor and his appointees would have final authority over authorizing projects and spending the bond revenues (67), and many legislators felt this would be tantamount to giving the Governor a blank check with no meaningful controls. Some others also felt that such power would usurp the legislative function and give the Governor complete control over California water development. This broad executive power and lack of statutory guidelines is currently a key issue in the much-publicized Peripheral Canal controversy. (See Chapters Four and Five.)

The 160-acre limitation, or lack thereof, played a supporting role in the battle. Some legislators felt that the Feather River Project was designed as a subsidy for large agricultural interests in the San Joaquin Valley, and they called for measures which would benefit the small farmer, at least by giving him cheaper water (68). The primary advocates of such limitations were Assemblyman Lloyd Lowrey and Senator Virgil O'Sullivan. Interwoven with these arguments was an element of preference for federal construction of water projects.

Another point of contention was using the Sacramento River as a "free" transportation canal at the expense of contiguous land owners. Problems were expected to arise from erosion and seepage damage occasioned by construction and operation of water projects. Assemblyman Lloyd Lowrey authored legislation to make water projects responsible for any such damage (69).

3. Legislative Action

Governor Brown's strategy was to attack the opposition in its Senate stronghold. If he could get the Feather River Project through the Senate, he felt confident of victory in the southern-dominated Assembly. Battle was first joined in the Senate when the California Water Resources Development Bond Act was introduced, as Senate Bill 1106 on March 31, 1959. The bill was introduced at the request of the Governor by Hugh Burns, and twenty-six other Senators representing counties from Humboldt to Imperial (70), and looked very different from the measure which eventually won approval. In three pages, SB 1106 authorized \$960,000,000 in general obligation bonds to finance construction and operation of units of the Central Valley Project. The bill was referred to committee where it lay until May 5, when Hugh Burns took the floor to urge the adoption of several amendments to the Bill. Out went the reference to the Central Valley Project; the authorized bonds were increased to \$1.75 billion; specific works were specified as were the basic repayment provisions. The "Davis-Grunsky Act" (for Assemblywoman Pauline Davis and Senator Donald Grunsky) which reserved \$130,000,000 of the \$1.75 billion for construction of local projects, primarily in northern California, was inserted. The amendments were adopted and the Bill went back to committee.

An interesting side note is the part that the executive branch played in the floor debates and committee discussions of SB 1106. Since neither Hugh Burns nor Carley Porter was intimate with the bond act's complicated provisions, they were each accompanied by Ralph Brody and Harvey Banks during the debates. Brody and Banks went right into the committees with Burns and Porter and onto the floors of both houses and fielded questions on the Bill.

After its amendment on May 5, SB 1106 remained in committee until May 15, when it returned to the Senate floor for amendments recommended by the Water Resources Committee. The important parts of these amendments allowed money to be spent on facilities of either the Central Valley Project or the California Water Plan, and guaranteed the sanctity of existing water rights legislation and vested water rights. Further amendments were adopted on May 20, May 26 and May 28, including one introduced on May 28 by Senator George Miller, Jr. of Contra Costa County which deemed the Sacramento-San Joaquin Delta a part of the Sacramento River watershed (71). This important amendment made the Delta an "area of origin" for

Sacramento River water. It also provoked opposition to the bill from water-short areas which were afraid Delta interests would have the power to shut off water exports if the water were ever needed within the Delta. That same day, other amendments intended to favor either north or south were defeated, often by only two votes. On May 29, an attempt by Sen. Virgil O'Sullivan to put in a 160-acre limitation failed. But the balance remained dead even. At this crucial moment, Governor Brown finally persuaded one of his closest friends, Senator Eugene McAteer of San Francisco, to vote for the bill. This vote broke the deadlock and enabled the Governor to get a few more votes (72). Shortly thereafter, the Senate voted 25-12 in favor of approving SB 1106. Not all the northern Senators voted against the bill, but all of those who did were northerners from water supply areas (73)— "mountain men" and "river rats" Hugh Burns has called them (74).

Carley Porter was expected to have an easier time in the Assembly than Hugh Burns had had in the Senate, and Porter is credited with doing a masterful job of managing the bill. It was critical that the bill get out of the Assembly unamended so that the Senate would not have another shot at it. This seemingly impossible task was accomplished, with a whole spate of amendments voted down on June 17, the same day the final vote on the bill was taken (76). The final margin of 50-30 does not, however, reveal the spirited and often bitter floor fight which took place in the Assembly. Old-time northerners like Assemblyman Lloyd Lowrey led the fight against the Governor's forces, joined by Pauline Davis, who did not like SB 1106, even with the Davis-Grunsky provisions, and Bruce Allen, who had supported SB 1106 until it was amended to make the Delta an area of origin for the Sacramento River. The final vote on a bill is not always a true assessment of the fight that has gone before, because once the outcome is clear, legislators will often cast or switch their votes to come out on the winning side. This is reportedly what happened with SB 1106 in the Assembly. Commentators have attributed the 50-30 vote to a more favorable balance for the south, masterful managing by Carley Porter, and pressure by the Governor. Evidence indicates that the Governor's pressure may have been crucial.

With the session running well into June, the legislators were anxious to finish up their business and adjourn. However, many Assemblymen were in favor of holding out for amendments to the Burns-Porter Act which spelled out the policy to be used in spending the bond revenues. The Governor and proponents of the measure urged adoption of the Burns-Porter Act as it was, and promised a special session in the fall for the specific purpose of amending the Burns-Porter Act (76). While the special session was never called, such a promise by the Governor during the press to adjourn may have swayed one or two skeptical Assemblymen.

According to former Assemblyman Lloyd Lowrey, the key factor in turning potential victory for the opposition into victory for SB 1106 was the timely promise of an appointment to a municipal judgeship made by Governor Brown to Republican southern California Assemblyman George Crawford (77). By Mr. Lowrey's account, the Governor stood to lose his bill in the Assembly. The opposition needed four additional votes to kill SB 1106, and the key to those four votes was George Crawford, who had indicated opposition to the bill. During the maneuvering, Mr. Crawford told Mr. Lowrey that he had been offered a judgeship in return for his support of SB 1106 and that he would support the bill. Assemblyman Crawford's support of

SB 1106 caused the three other "swing votes" to go for the bill. The bandwagon effect was good for six more votes to produce the final 20-vote margin.

Judge Crawford takes exception to Mr. Lowrey's account, and recounts his own role in the struggle this way (77):

> I consider that the success of Senate Bill 1106 was due to the efforts of then Assemblyman Jack Schrade and myself organizing votes on the floor of the Assembly. We did this in opposition to the attitude of the Metropolitan Water Authority, who had indicated that we in San Diego would never receive an adequate supply of water if they had their way. I was in favor of Senate Bill 1106 from the very beginning and gathered support which caused the success of this Bill. It is my opinion that if it had not been for Assemblyman Jack Schrade and myself, Senate Bill 1106 would have failed.

Governor Brown emphatically denies that he ever offered a judgeship on any subject in the legislature. He says, "Some assemblymen may have thought I had and I did put pressure on the Legislature of a legitimate kind (78)."

Whatever were the ultimate factors, the Governor's overall strategy paid off. SB 1106 passed by substantial, but less than two-thirds, majorities in both houses and was signed into law by Governor Brown on July 10, 1959. The Burns-Porter Act was ready for the people.

F. Proposition 1

A provision in the Burns-Porter Act called for its submission to the electorate in the November, 1960 general election. As Proposition 1 on the ballot, the Burns-Porter Act hit the campaign trail. To completely defuse a possible partisan campaign by the opposition, Governor Brown selected two prominent Republicans as his statewide and southern chairmen for Proposition 1. Statewide, Thomas J. Mellon, a former campaign chairman for U.S. Senator Thomas Kuchel, and in the south, L.A. Mayor Norris Poulson, helped map the strategy to put Proposition 1 over.

All during 1960, the battle over Prop. 1 was waged. Proponents of the measure predicted a million-vote margin, but realistically they must have expected a much closer fight. The press divided on the issue. Many smaller papers in the urban coastal and southern areas supported the project. The San Francisco *Chronicle* staged an acrimonious opposition, while the San Francisco *Examiner*, Sacramento *Bee* and Los Angeles *Times* were staunchly behind the Governor's water plan. Although Governor Brown still stings from the *Chronicle*'s attacks (80) Thomas Mellon was pleased with the overall press support of Prop. 1 (81).

Support came, too, from a wide variety of business and civic groups, including the California Savings and Loan League, Irrigation Districts Association, League of Women Voters, Farm Bureau, League of California Cities, State Chamber of Commerce, and numerous local chambers of commerce. Many city councils and county boards of supervisors, including the supervisors of San Francisco and Santa Clara counties, rallied behind Prop. 1. Labor support came from construction unions and from the powerful Teamsters (82).

But the opposition was formidable. The Metropolitan Water District opposed the bonds until just a few days before the election. The California Federation of Labor (AFL-CIO) threw its weight against the measure. The prestigious Commonwealth Club of San Francisco, as well as the San Francisco Chamber of Commerce came out against Prop. 1. The state's small farmers voiced their opposition through the Grange (83). Few people doubted the scientific data collected by the Department of Water Resources on the amount of water available in California, but many people doubted the Department's estimate of California's water needs. Many taxpayers feared that the huge bond issue, at that time the largest of its kind in the nation's history, would increase their taxes, despite assurances by the Governor to the contrary. The Grange wanted no part of a project designed expressly to circumvent the 160-acre limitation. The California Federation of Labor, with the exception of some of its construction elements, saw the Feather River Project as a giveaway to landed interests in the Central Valley, and were opposed to anything that would aid those who fought against unionizing the farm workers.

The campaign aroused almost as much interest as did the presidential campaign between John Kennedy and favorite-son, Richard Nixon. It was also one of the most expensive campaigns on behalf of a ballot measure in the state's history to that time (84). And, with all of the side issues and technical data being thrown around, it was confusing. The San Francisco *Chronicle* wrote on April 29, "People Face Blind Vote on Water." A field poll taken in July revealed that voters favoring the proposition were most concerned about the need to meet the demand for more water, while those opposed thought the water supply was adequate and were afraid the Feather River Project would raise taxes (85).

The confusion was compounded when the reports of two independent consultant firms, Dillon, Read and Co. of New York, and Charles T. Main of Boston, hired by the Governor to review the Feather River Project, were released simultaneously on October 27. They both found the engineering of the Feather River Project to be sound, but both questioned the financial integrity of the Project (86). They suggested delaying certain capital expenditures – in particular the Oroville Dam – for up to twenty years. The Los Angeles *Times* reported "Feather River Project Gets Sound Rating in Two Reports." The San Francisco *Chronicle* wrote "State Water Plan Called Impossible." During the campaign Harvey Banks submitted his resignation as Director of the Department of Water Resources, effective January 1961. A few days before the election, fifty-three economists, engineers and professors from leading California Universities issued a 10-point warning about the engineering and financial shortcomings of the project (87). Only six days before the election, the Metropolitan Water District reversed its strong opposition and voted to support Prop. 1. The average voter must have been hopelessly confused.

On November 8, the voters made their decision. By a 80,000 vote majority, Proposition 1 carried (88). The vote was clearly along north-south lines, indicating that all the sophisticated arguments may not have meant much in the end. It is probably not too far from the truth to say that the fear of thirst in the south simply overcame the fear of the south in the north and carried the Feather River Project to victory on November 8, 1960.

G. Analysis and Comment

It may never be possible to tell conclusively whether the legislature and the voters made a wise decision in approving the Burns-Porter Act and making possible the construction of the Feather River Project. About the most that may now be said with any degree of certainty is that the decision was a logical one in light of California's history.

Projects to control, conserve and convey water have been accepted as necessary and desirable in California from the time of the first European settlers. Such works are essential for any but the most basic of societies. The "growth ethic" which equates well-being with economic achievement and views increased population as necessary for economic growth reached California with a vengeance during the gold rush of the mid-1800's, increasing the desire and need for controlling California's water resources. The predominant concern through the 1950's was that the failure to control water would limit California's economic and social growth. The Federal Reclamation Act, the State Water Plan of the 1920's, the Central Valley Project and the California Water Plan with its Feather River Project were all attempts to meet this concern. And while people lured to California by the dream of riches may not have understood complicated arguments of high finance, they understood well enough that their dream depended upon a reliable water supply.

Engineers like A. D. Edmonston can hardly be faulted for making grand designs to control the state's waters. Engineers were trained to build; people had almost a blind faith in the ability of engineers to solve complex problems with the slip of a slide rule. What better way to serve the people of California than by building monumental water works? Engineers can be criticized for being too quick to embrace monumental dams and aqueducts, too slow to bend their slide rules to water reclamation and waste treatment. However, this criticism says only that the engineers were products of their time.

Businessmen and large farmers may be criticized for putting personal gain ahead of the State's welfare. But according to the growth ethic, what was good for business was good for the state. Greater criticism can be levelled at those who preached free enterprise while fighting for greater public subsidies for themselves through cheap water from federal projects.

Governor Brown's motives appear to have been unimpeachable. One searches in vain for a hint that the Governor had anything in mind but the best interests of California when he undertook to promote the Feather River Project. Whatever were the reasons of other public representatives for supporting water development, Governor Brown's motives seem above reproach.

If the motives of many water project advocates are not open to valid criticism, there still remains the matter of how they acted on their concerns. Here the criticism of short-sightedness and myopic concern with monuments is more telling against all parties. Waste water treatment and reclamation received scant attention. The possible environmental effects of the huge federal and state water projects were not known, and were considered unimportant when they were considered at all. Assemblyman Lowrey's plea for ten million dollars to study the potential environmental effects of both the Feather River Project and a drainage canal for agricultural waste water in the San Joaquin Valley was ignored (89). And even if the concept of supplying California's water needs through dams and aqueducts is valid, there still remains a

worry that questionable tactics such as bringing pressure on the legislature unrelated to project merits and misleading voters on the cost of the project and project water helped produce unwise results.

H. California State Water Project.

With the passage of Proposition 1, the concept of water as an inexhaustible free resource was laid to rest in California. And the concept of water as a renewable resource was amended to a concept of water as a precious commodity, with the Department of Water Resources as packager and distributor. This latter point bothered some opponents of the California Water Plan, and also bothered Harvey Banks. They argued that it was dangerous to have the planners become salesmen, because it would be too easy for the plans to become completely customer-oriented. Despite these misgivings, the Department of Water Resources was in the water supply business in a big way.

Under its new director, William Warne, the Department continued in 1961 to acquire rights-of-way, finalize planning and begin construction on units of the Feather River Project (90). Actual construction began first on the South Bay Aqueduct, followed by the California Aqueduct, the Oroville Dam, and numerous other dams. Two crucial lawsuits decided by the California Supreme Court in 1963 helped provide financial stability for the Project. The *Metropolitan Water District v. Marquardt*, 59 Cal. 2d 159, 379 P. 2d 28, recognized as lawful the issuance of the authorized bonds and the validity of the water supply contracts entered into by the Department. *Warne v. Harkness*, 60 Cal. 2d 579, 387 P. 2d 377, held that the Burns-Porter Act did not repeal the authority given the Department of Water Resources in the Central Valley Project act to issue revenue bonds. The general obligation bonds were the backbone of the Feather River Project, and the revenue bonds were needed to provide a cushion for any cash squeezes. About this time, the Department of Water Resources Director William Warne brought nomenclature into conformance with reality by ordering that the "Feather River Project" be renamed the "California State Water Project."

One of Governor Brown's selling points for the Feather River Project had been the need for flood control on that river. In 1955 the Feather River had inundated Yuba City, killing 36 people and destroying 400 homes. In 1964 a potentially more disastrous flood was stopped by the partially-completed Oroville Dam, saving an estimated $30 milllion in property damage (91). Governor Brown felt that this incident alone vindicated his support of the Feather River project (92).

Southern California received a sharp jolt in 1963 when the United States Supreme Court decided against California in its lawsuit with Arizona over the right to Colorado River water. The decision would have no immediate impact on the amount of water southern California received from the Colorado River, but meant that eventually California might have to give up 1.5 million acre-feet of water per year to Arizona. In the face of continuing population growth, southern California representatives looked to the State Water Project to make up part of this prospective loss. The Department of Water Resources recognized the problem and began to renegotiate its water supply contracts. The original diversion of water had been set at 2.25 million acre-feet annually to the San Joaquin Valley and 1.8 million acre-feet annually to southern California. After renegotiation of the water supply contracts, the figures were 1.34 and 2.5 million

acre-feet, respectively (93). The State Water Project had to be redesigned to meet the changed needs, and the redesigned project would be more costly. Even with increased tidelands oil revenues and the sale of revenue bonds, there was a projected deficit of $300 million in 1966 (94). The outcome of the renegotiations also underscored the migration of economic and political power to the south, aided by forced legislative reapportionment in 1963. The south would hold all the high cards in any future dealings with the north (95).

The loss of almost 1 million acre-feet of water to southern California was a nasty shock to the San Joaquin farmers, made worse because the State Water Project was getting more expensive as construction costs rose. The price of water delivered to Kern county which had been quoted at $15 to $18 per acre-foot in 1959 jumped to $21 shortly after the 1960 election. This price is too high for the economic production of many agricultural crops. Even for the crops which have a high enough profit margin to make the use of such expensive water possible, there is a period of loss before the crop (e.g., fruit and nut trees) is brought into full production. The San Joaquin Valley farmer's dilemma was mitigated by the state's agreeing to supply essentially free water for a number of years.

This scheme would be possible because of the difference in time between completion of the Central Valley portions of the State Water Project, and the completion of the Tehachapi portion of the project in the southern part of the state and development of water needs there. The Central Valley portion would be completed in about 1968. The Southern California portion would be completed about four years later, and full use of the southern division would not be achieved until 1990. During most of this time, while the State Water Project would be capable of delivering water contracted for by Valley farmers, there would also be available all of the water which was contracted for by the south, but which couldn't be delivered until the Tehachapi division was completed (96). This "surplus" water would be delivered to Valley farmers for only the cost of transportation (97). The cheap water would allow the farmers to bring their crops into full production by the time they would have to pay the full rate for all of the water they received (98). Since the implementation of this scheme, agricultural economists have warned that the thousands of acres of fruit and nut trees planted by Valley agricultural interests during this start-up period will have a serious impact on the state-wide agricultural economy when full production begins (99). The most likely effect will be to drive many of the smaller fruit and nut producers in northern California out of business. It can be argued that if products can be produced more efficiently and cheaply they should be. However, it can also be argued that these economies will not benefit the consumer, and that the small farmer is being forced to subsidize the larger Valley interests. The Department of Water Resources adopts the view that agriculture has changed to meet changed conditions before and it can do so again (100).

By 1966, much of the State Water Project was already completed or under construction, virtually precluding any major revisions in the Plan, other than additions to it (101). Governor Brown and the planners in the Department of Water Resources were making plans for additions, one of the first of which was to be a dam on the middle fork of the Eel River. This project would supply some flood protection to the North Coastal area and develop another 900,000 acre-feet firm yield of water annually for the State

Water Project. But winds of change were blowing. Governor Brown was defeated in his bid for re-election by Ronald Reagan (102).

Reagan had demonstrated during the campaign a collossal ignorance of California's water problems. He sought to compensate for his ignorance by appointing as Director of the Department of Water Resources, William Gianelli, a northern Democrat who was regarded by all knowledgeable persons as the most qualified man in the state for that post. Gianelli brought to the job a detailed knowledge of water development in California, boundless energy, political savvy, and intense devotion to the California Water Project. However, Governor Reagan also brought with him a passion for tight spending, and a conservationist Resources Secretary. These factors combined against Gianelli in 1968, to delay proceedings on the Eel River Project – only one of many setbacks Gianelli would face in his quest to complete the State Water Project. He has perhaps the toughest job of any Department of Water Resources Director as he has faced a rip-tide of political change, perverse economy, and adverse scientific evidence.

I. Adversity for the State Water Project.

After the big battle in 1960 was decided in favor of constructing the Feather River Project, and a last-ditch try at amending the Burns-Porter Act in the 1961 legislative session failed, most of the project's critics remained critical, but turned their energies to other tasks. This was not true of a small group of opponents in Contra Costa county, who resembled the Alamo defenders in their truculence and tenacity. Their concern was that exportation of water from the Sacramento River would result in degradation of the San Joaquin Delta waters upon which the county's economic base was built, and they wanted a guarantee of water quality. Whether that meant less water exported from the Delta or more water imported to the Delta, at least some of them didn't really care (103). For eight lonely years, they waged an uphill and losing battle which was marked by a defection in their ranks (104). Then, in 1969, the Contra Costa holdouts were presented with an incredible and unexpected political windfall called the "Environmental Movement." Suddenly, Congressman Jerome Waldie found himself with thousands of not only allies, but disciples, all screaming for the Department of Water Resources' scalp and a halt to the State Water Project.

The environmental movement was based on some data made possible by newer technologies, but primarily upon a holistic concept of nature and man's place in nature. This concept, while quietly simmering for years in biological circles, boiled over to sweep the nation almost overnight. It had two important implications for the State Water Project. First, it foreshadowed an attempt to limit population growth in any given area. If the population in southern California were so limited, the projected water needs which had seemed so accurate only a few years before would never develop, or develop much more slowly. Second, ecological concepts embodied a redefinition of what was meant by "conservation," including water conservation. It just might be that engineers and politicians would have to think again when they said that "surplus" was "wasting" to the sea, when it could be stored behind a dam and put to some use for the "benefit" of man.

A number of scientific studies undertaken by government agencies during the 1960's also proved a

major headache to William Gianelli. The Federal Water Pollution Control Administration released a report in 1967 which projected adverse economic consequences for the San Joaquin Delta area if the San Luis Drain unit of the Central Valley Project were built and operated according to plan (105). This criticism was met by the Department of Water Resources and the Bureau of Reclamation with claims that any adverse effects could be mitigated by the already existing substitute overland supplies (106).

Mr. Gianelli claimed that the FWPCA's conclusions were based upon calculations that failed to include overland supplies, and were therefore incorrect (107). In 1968, a preliminary report was tendered by the California Department of Fish and Game projecting adverse effects on the Delta fishery (108). This report was followed by a Department of Water Resources announcement of operating criteria aimed at minimizing fishery losses (109) and a shake-up in the Department of Fish and Game (110). In 1970, the U.S. Geological Survey published a preliminary report indicating that the export of water from the Delta in the amounts planned by the Department of Water Resources could have serious adverse effects on water quality in San Francisco Bay (111). The Department of Water Resources simply denied the implications of this preliminary report and questioned the study's usefulness for purposes of water planning and management (112). Dr. Robert Rex of the University of California at Riverside announced that there were vast underground reservoirs of steam beneath southern California which might be tapped to provide electrical power and water at less cost than the State Water Project water. This possibility is currently being investigated by the Department of Water Resources (113).

Another major unforeseen development was a period of spiraling inflation coupled with a period of "tight money," which made all state bonds, which were subject to a constitutional interest rate limitation, unsalable. This included $600 million of unsold water bonds. To remedy the situation, a statewide election was set to increase the allowable interest rate on all state bonds, the election to be held in June, 1970. Old-time opponents of the State Water Project, joined by their new-found allies, smacked their lips over the possibility of defeating the interest override and leaving the State Water Project without sufficient money to allow for completing the project. Because Proposition 7 raised interest rates on other bonds, for example school and veterans bonds, it is hard to tell what factor was decisive. But once again, the water fight was reduced to simplistic, absolute and polarized terms. Opponents of the Project, led by Rep. Jerome Waldie, told of environmental disaster if the water project was allowed to go through to completion. The Department of Water Resources, ably led by William Gianelli, foretold of economic disaster for the state's taxpayers if the project could not be completed and the taxpayers got stuck for paying for a 95% complete, but useless, water conveyance system. The project's opponents made some attempts to talk of alternatives to the project, but the Department of Water Resources refused to admit even the possibility that viable alternatives existed. What neither side clearly pointed out was that by completing the Feather River Project component of the State Water Project, scaling down delivery of water to the state's contractors and abandoning certain projected facilities like the Dos Rios Dam, both economic and environmental losses could be minimized and balanced (114). Clear need for the sale of non-water project bonds, coupled with the predictions of huge demands on the taxpayers should the water bonds not be sold, carried the election

for the interest override, and completion of the State Water Project was all but assured. At the same time, the voters approved another ballot measure, Proposition 20, which authorized the sale of $60 million in general obligation bonds to finance public recreation and fish and wildlife enhancement facilities for the State Water Project (115).

In September, 1970, the Metropolitan Water District released the results of a study which it said showed that population projections were less than previously estimated, that loss of Colorado River water was not so imminent as once believed, that water use per capita for domestic uses was down, and that waste water reclamation showed more promise than previously estimated (116). The principal conclusion of the study was that the State Water Project would serve to meet growing water demands for a longer period of time than estimated previously, perhaps 20 to 30 years (117). An October, 1970 clarification of the report shows that State Water Project water will be required, not because of a water shortage, but because of a desire for higher quality water than that obtainable from the Colorado River (118). The possibility of voluntarily reducing Colorado River water imports as State Water Project imports increase is also mentioned (119). The Metropolitan Water District's findings foreshadowed those of the Department of Water Resources in *Bulletin 160-70, Water for California. The California Water Plan Outlook in 1970*, published in December, 1970.

Bulletin 160-70 recognizes the changes in population growth, availability of Colorado River Water and improved technologies since the publication of *Bulletin 160-66*.

The Department of Water Resources expects the declining rate of demand to delay the need for expanding the State Water Project for more than 20 years. In addition, the Department recognizes the emergence and increasing importance of environmental concepts and the impact these new concepts will have on resource planning in the future. Since the State Water Project is designed primarily to benefit export water contractors, it will be interesting to see how environmental concerns influence present and future water planning. One healthy sign is recognition by the Department of Water Resources in *Bulletin 160-70* of the political importance of environmental issues, and the consequent need to include environmental concerns in resource planning. However, the primary worry of the Department still seems to be that of defaulting on its water supply contracts (120). Gianelli stated on February 9, 1970 to the Assembly Water Committee, that, "As a strictly legal proposition, it is probably not true that the State has a binding obligation to supply water under its contracts." As a statement that government should fulfill the reasonable expectations and keep the confidence of its constituents, the proposition has greater validity. However, the moral argument is weakened by the contract renegotiations which occurred in 1963 to the detriment of Central Valley contractors expectations. Obviously, there may be changes in conditions significant enough to justify frustrating the expectations of at least some contractors.

It is further interesting to note that the *Bulletin*'s recognition of no urgency in supplying water to southern California bears out the validity of some earlier criticisms of the Feather River Project.

One aspect of water supply that is given more emphasis in *160-70* than in either *Bulletin No. 160-66* or *Bulletin No. 3* is the need to provide good quality water to all areas of the state. This emphasis is

primarily a recognition of the importance of water quality as opposed to merely the quantity of water delivered, the emphasis may also be designed as partial justification for the State Water Project, now that the water crisis has not developed according to plan in southern California. Thus, the Department of Water Resources may be invoking a kind of fairness doctrine to justify causing a net degradation of water quality in one area to improve the water quality in another area (121). For, except in dry years, the Sacramento-San Joaquin Delta will experience a net overall degradation of its water supply under projected full operation of the State Water Project.

J. The Central Valley Project Today

The above discussion has dealt almost exclusively with water development by the State of California, with but brief mention of the Federal Central Valley Project. However, in terms of total water developed and managed, the Federal project is by far more important. For example, the Federal project currently supplies about 6.2 million acre-feet of water per year, while the State project supplies only 0.6 million acre-feet. By 1990, the estimated figures are 10.7 million acre-feet and 3.5 million acre-feet respectively (122). It is obvious that in terms of today's most popular issue – the environment – the Central Valley Project has greater potential than the State project for adversely affecting the environment. Furthermore, two of the most controversial water development projects today are the Peripheral Canal, a joint Federal-State project, and the U.S. Bureau of Reclamation's San Luis Drain. Thus, any discussion of the effects of water development should include the Federal project, and not focus exclusively upon the State Water Project.

IV. Water Rights.

When the Gold Rush brought large numbers of settlers to California in the late 1840's, a need arose to decide between conflicting claims to water. The miners followed the same procedure that was used for their mining claims, and filed claims to specified amounts of water (123). The first person to file a claim to water from a specified source had the superior right to that water. This same procedure came to be followed by others as an orderly way to ration the water supplies. In 1872, the California legislature enacted this custom into law, and specified a procedure to be followed in *appropriating* water (124). The "first in time, first in right" custom obviously made the most sense for deciding water rights conflicts in a water-scarce area, and the system was adopted by other western states (125).

Unfortunately, the legislature had in 1850 passed a law calling for the adoption in its entirety of the English Common Law. This provision was continued in effect after California became a state (126). The common law of England settled water rights conflicts by assigning a superior right to all persons whose land bordered on a stream or lake. This *riparian* system of water law, having developed in water-rich England, looked upon water as a basically inexhaustible resource and made no provisions for persons who had first begun to use water on land not bordering upon the source of the water. Furthermore, the riparian owner could use all the water he wished on his land, as long as he did not impair the use of water by another

owner riparian to the same source. Despite the confusion this riparian system caused in California, riparian rights were held superior to appropriative rights in two landmark decisions by the California Supreme Court (127).

By the time the second decision was rendered, the water shortage had become acute enough in most of California, and the idea of water conservation had gained enough popularity, that the response was a constitutional amendment passed in 1928 (128). It provides that all uses of water should be limited by reasonableness and that riparian rights must show reasonable needs and methods of use to be entitled to prevent use by others. The key sentence reads, "The right to water or to the use of flow or water in or from any natural stream or water course in this state is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water." Thus, the doctrine of "reasonableness" was established for all water users – both riparian and appropriative – within the state.

The California Supreme Court has had many occasions to apply the reasonableness doctrine and to define what was meant by "reasonable and beneficial" use. One requirement developed by the court is that a use must be *both* beneficial and reasonable in order to gain priority over another right. While the legislature has continually expanded the statutory definition of beneficial use (129) to include aesthetic enjoyment, as a beneficial use, along with the other uses: domestic; municipal; agricultural and industrial supply; power generation; recreation; navigation; and preservation and enhancement of fish, wildlife and other aquatic resources or preserves, the court has been left free to decide in each case whether a beneficial use is ***reasonable***. A reading of the cases will show that the court's concept of reasonable use has been based upon the "savings bank" concept of conservation which was developed early in the century (130). One of the latest and key cases decided by the Supreme Court is *Joslin v. Marin Municipal Water District*, 67 Cal. 2d 132, 429 P. 2d 889 (1967), in which the court cited a constitutional mandate that conservation be exercised "in the interest of the people and for the public welfare" and decided that an upstream municipal appropriator had superior rights to a downstream riparian owner who relied on the stream to deposit gravel for his gravel business. This case is less significant for its specific holding on the gravel bed question than for the reasoning that the court used in arriving at that decision, because it shows that the court was relying on the traditional concept of conservation.

Here the ecology movement again becomes important, because as previously noted, ecological concepts are forcing a redefinition of what is meant by "conservation." Almost certainly in the near future, the court must come to grips with this redefinition process in deciding what uses are reasonable *vis a vis* other uses. Such a case, for example, might force the court to decide between southern California users who use Sacramento River water to dilute the harder Colorado River water for both agricultural and municipal purposes and the riparian owners in the Delta who want to use Sacramento River water to repel saline ocean water or dilute wastes from the San Luis Drain.

V. Summary and Conclusion.

California has approximately 2/3 of its surface water in the northern half of the state, whereas people have chosen to settle primarily in the southern half of the state. This imbalance has led to chronic water shortages for human activity and motivated water development projects at least since the time of the first Spanish missionaries. As the human population of California increased, water projects and planning for water supply grew in scope, as did conflicts over the right to use water from any given source. During this time, the whole concept of water changed from an inexhaustible free resource to a rare commodity, and water supply became increasingly expensive and a matter of political concern. Water engineers have dreamed since at least the turn of the century of ending California's water imbalance by harnessing northern California's waters behind dams and conveying them to the southern half via a series of aqueducts. This dream was realized to a great extent by construction of the Central Valley Project, designed to provide the San Joaquin Valley with water for agricultural purposes. It is being realized further by the State Water Project which was originally motivated by agricultural interests, but has now become predominantly urban-oriented as economic and political power have migrated to southern California urban centers.

The implementation of the Feather River Project as the first unit of the California Water Plan was a study in shrewd political maneuvering. But as the time nears when the first water will be exported south of the Tehachapis, California has yet to come to grips with the environmental implications of its water project and has yet to solve all the problems of the project's financing.

Many of the criticisms of the Feather River Project appear to have been accurate. Californians are all paying – directly or indirectly – for a premature water project that was sold to them by men whose intentions ranged from base to noble. These factors do not preclude the possibility that the Feather River Project was the best project obtainable for the state because of a necessity to compromise. Whatever the merits of the State Water Project relative to other possible water systems, the Project has already supplied flood control and water supply benefits and will provide more benefits in the future. It is not clear that existing facilities of either the Central Valley Project or the State Water Project have yet produced significant adverse environmental effects. But evaluation of environmental effects is hampered by lack of scientific information.

Californians should not be misled into thinking that the only alternatives facing them are ecological disaster or complete abandonment of a three-billion-dollar investment. Complete abandonment is not possible unless the Oroville Dam, the California Aqueduct, and numerous other structures suddenly disappeared; and even if they did, abandonment is probably not necessary from an environmental standpoint. On the other hand Californians should not blindly regard the plans of federal and state bureaucrats as infallible and necessary. There is obviously a point beyond which it would be pure folly to grossly tamper with the natural environment, just as there comes a point when new technologies offer better solutions. Once either of those points is reached it is nonsense to speak of "mandates of the people" and "contractual commitments." We must remain flexible, and conduct intensive scientific inquiries into the environmental effects of any and all water development, conservation or control projects, with this information made

freely available to the public so that future decisions may be based upon more reliable information than past decisions have been. Once environmental effects are better understood, they can be weighed against possible economic and social effects to determine the optimum solutions for all of California.

Important Dates in California Water Development*

1773 Construction of Old Mission Dam begins at San Diego

1849 Gold Rush

1850 California admitted to Union. Adopts common law of England with riparian system of water rights.

1872 Legislature adopts statutes defining appropriation rights.

1887 Passage of first irrigation district act (Wright Act).

1902 Congress passes first Reclamation Act.

1905 Los Angeles voters approve Owens River aqueduct bonds. Pacific Gas and Electric Company is incorporated.

1913 Owens River aqueduct completed. Congress authorizes Hetch Hetchy Reservoir inside Yosemite National Park.

1916 Conference on state water problems is called by the state legislature.

1921 State legislature authorizes comprehensive water resources investigation.

1927 Authorizations of appropriations of water by the state and preference to counties of origin.

1928 Adoption of constitutional amendment requiring all uses of water to be reasonable.

1931 *Bulletin 25* ("State Water Plan") published.

1933 Voters authorize $170 million worth of revenue bonds for Central Valley Project; bonds not sold.

1935 Bureau of Reclamation takes responsibility for CVP.

1936 Acceptance by Congress of federal responsibility for flood control.

1944 Shasta Dam finished.

1945 "Water Resources Act" passed authorizing complete inventory of land and water resources and a plan for water development.

1951 State Engineer Edmonston publishes *Report on Feasibility of Feather River Project and Sacramento-San Joaquin Delta Diversion Projects Proposed as Features of the California Water Plan*. State legislature authorizes Feather River Project. *Bulletin No. 1, Water Resources of California*, published by Water Resources Board.

1952 *Arizona v. California* suit filed before U.S. Supreme Court.

1955 State Engineer publishes *Program for Financing and Constructing the Feather River Project as the Initial Unit of the California Water Plan*. Report reviewed by Bechtel. Water Resources Board publishes *Bulletin No. 2, Water Utilization and Requirements of California*. Feather River floods Yuba City; gives impetus to Feather River Project plans.

1957 State Department of Water Resources created, along with California Water Commission, and Water Rights Board. *Bulletin No. 3, The California Water Plan*, published.

1958 Legislature deadlocks on issue of transporting northern California water to central and southern California.

1959 "California Water Resources Development Bond Act" introduced as SB 1106 on March 31. SB 1106 passed by Senate on May 28. SB 1106 passed by Assembly on June 17 after amendments fail. SB 1106 signed by Governor Brown on July 10, puts $1.75 billion on 1960 ballot for voter referendum.

1960 Campaign over Bond Act as Proposition 1 on November ballot continues all year. Proposition 1 passes by ratio of 1.06:1. Harvey Banks resigns during campaign, stays on till end of year, as Director of DWR.

1961 William Warne appointed Director o DWR.

1963 California Supreme Court decides *The Metropolitan Water District v. Marquardt*, and *Warne v. Harkness*, thus helping the State Water Project's financial stability. U.S. Supreme Court decides against California in its water suit with Arizona, giving impetus to revision of SWP and renegotiation of water supply contracts.

1964 Partially completed Oroville Dam prevents damage from December flood; North Coast shown vulnerable to floods.

1965 Interagency Delta Committee recommends peripheral canal as Delta unit of CVP and SWP.

1966 *Bulletin No. 160-66* published. Ronald Reagan elected Governor of California.

1967 William Gianelli becomes Director of DWR.

1969 Dos Rios Dam planning delayed. Environmental Movement begins.

1970 *Bulletin No. 160-70* published; shows assumptions underlying *Bulletins No. 3* and *No. 160-66* to be no longer true.

* Sources: *Aqueduct Empire*, by Erwin Cooper; *Water in California*, by S. T. Harding. For a more complete historical presentation, consult these sources.

FOOTNOTES

1. S. Harding, *Water in California*, (Palo Alto, California: N-P Publications), 1960, p. 12.

2. State of California, Department of Water Resources, *Bulletin No. 3: The California Water Plan*, 1957, Plate 2.

3. Equivalents for common measures of water are: 1 acre-foot = 325,851 U.S. gallons = 43,560 cubic feet; 1 cubic foot per second (cfs) = 646,317 U.S. Gallons per day = 1.9835 acre-feet per 24-hour day (usually taken as 2); 1 million gallons per day = 1.5472 cfs = 3.07 acre-feet per day. U.S. Department of Agriculture, *Yearbook of Agriculture*, 1955, p. 721.

4. E. Cooper, *Aqueduct Empire*, (Glendale, California: The Arthur C. Clark Co.), 1968, pp. 19-34.

5. State of California, Department of Water Resources, *Bulletin No. 160-70: Water for California: The California Water Plan Outlook in 1970*, 1970, pp. 69-70.

6. *Op. Cit.*, p. 172.

7. *Bulletin 160-70*, p. 5.

8. *Ibid.*, p. 47.

9. *Ibid.*, p. 63, 67.

10. *Ibid.*, p. 48.

11. *Ibid.*, p. 63.

12. Cooper, p. 418.

13. *Ibid.*

14. *Ibid.*, p. 53.

15. U.S *Reclamation Act*. 32 Stat. 388, as amended, 43 U.S.C. paragraph 371.

16. Cooper, p. 419. A narrative of these two conflicts appears in Cooper's book at pp. 54-68.

17. Cooper, p. 66.

18. R. Cunningham, "Water Quality in the Sacramento-San Joaquin Delta," *U.C.D. Law Rev.*, 1:209.256, 1969.

19. Cooper. p. 47.

20. See note 131, *infra*.

21. The 1933 vote carried by a margin of 1.1 to 1.0, on the strength of a heavily favorable vote in the northern counties. See Graham, *infra*, note 22, p. 58., note 195. This vote represented a major achievement for Assemblyman John O'Donnell, who championed the Central Valley Project in the Legislature.

22. Leland O. Graham, "Some Aspects of Federal-State Relationships in California Water Development (Duplication Process), 1961, p. 19. The signing occurred on December 2, 1935.

23. See, e.g., U.S. Act of May 25, 1926, ch. 383, paragraph 46, 44 Stat. 649, as amended, 43 U.S.C. paragraph 423e; F.C.A. 43 paragraph 423e.

24. For a brief treatment of some problems involved in enforcing reclamation policy see the statement of Paul S. Taylor in U.S. House of Representatives Committee on Government Operations, Subcommittee on Conservation and Natural Resources, *Hearings*, 91 Cong. 1st Sess., *The Nation's Estuaries: San Francisco Bay and Delta, California*, Part 2, at 529.

25. Graham, p. 146.

26. Cooper, p. 168.

27. Graham, p. 29; Cooper, p. 160.

28. Graham, pp. 29-34; Cooper, p. 160.

29. George Ballis, *An Evaluation: The California Water Plan*, (Washington, D.C.: Public Affairs Institute), 1960, p. 4. A variation on this scheme was tried later by the Department of Water Resources and the Corps with the Eel River Dos Rios Dam project, where flood control and recreation benefits were used to justify a water development project. See *California Engineer*, October, 1970, p. 10.

30. December 22, 1944, c. 665, paragraph 8, 58 Stat. 891; 43 U.S.C.A. paragraph 390.

31. Stats. 1945, c. 1514.

32. Stats, 1947, c. 1541.

33. State of California Water Resources Board, *Bulletin No. 1: Water Resources of California*, 1951; *Bulletin No. 2: Water Utilization and Requirements of California*, 1955; California Department of Water Resources, Division of Resources Planning, *Bulletin No. 3: The California Water Plan*, 1957.

34. Cooper, p. 128.

35. Ballis, p. 4.

36. Stats, 1951, c. 1441; Water Code paragraph 11260.

37. Cooper, pp.202-204. Sometime between 1951 and 1955, Bureau of Reclamation plans for the Feather River Project were quietly shelved. See Ballis, p. 4.

38. Quoted in Ballis, p. 3.

39. Stats. 1956, 1st Ex. Sess, c. 54, p. 429, paragraph 1. The Legislature reauthorized the project twice thereafter in 1957 and 1959. See Water Code paragraph 11260.

40. Interview with Harvey O. Banks, Belmont, California, December 23, 1970. (Hereinafter referred to as Banks Interview). See also Harding, p. 200.

41. Cal. Stat. 1956 (Ex. Sess.), c. 52.

42. Harding, p. 200.

43. Hugo Fisher, *California, The Dynamic State*, (Santa Barbara, California: McNally and Loftin), 1966, p. 109.

44. Banks remembers the date as 1990 in a letter to Lloyd Lowrey, Jr., (hereinafter referred to as Banks Letter) March 2, 1971. However, at the time the Burns-Porter Act was passed, the planning date was set at 1985. See Remarks of Harvey O. Banks before California Press Association, Clift Hotel, San Francisco, California, December 5, 1959; comments of Harvey O. Banks before the 61st Annual Conference, League of California Cities, Curran Theater, San Francisco, California, October 19, 1959. This difference in planning dates could, along with inflation, help explain the confusing finances of the Feather River Project. To add further to the complexity of the matter, *Bulletin 160-70* continually refers to planning target date of 1990. This fact raises the problem that in 1959, the voters approved financing for one plan, but are now paying for another version.

45. Banks Interview.

46. Letter from Ralph Brody to Lloyd Lowrey, Jr., March 10, 1971. (Hereinafter referred to as Brody Letter)

47. Banks Letter; Brody Letter.

48. Cooper, p. 221.

49. State of California Constitution, Article XVI, sec. 1.

50. State of California Constitution, Art. XVI, sec. 1. This section was amended in 1962 to require a two-thirds vote of the Legislature. See, State of California, Department of Water Resources, *Alternatives for State Water Construction and Financing through 1975*, September 1967, Appendix B, p. 2.

51. California Senate Bill 1106 (Reg. Sess., 1959), p. 2., lines 15-22 – Now, Water Code paragraph 12931.

52. California Senate Bill 1106, pp. 3-4. Now, Water Code paragraph 12937.

52. Senate Bill 1106, p. 6, lines 7-11. Now, Water Code paragraph 12937.

54. State Senators Virgil O'Sullivan and George Miller, Jr. quoted in Ballis, p. 2.

55. Fisher, p. 113.

56. California Assembly Journal, 1959 Reg. Sess., pp. 2-3; California Senate Journal, 1959 Reg. Sess., pp. 2-3.

57. Los Angeles *Times*, Monday, November 7, 1960, part III, p. 1.

58. See, e.g., San Jose *Mercury*, "Low Wells Bring No Yells – Yet," Wednesday, November 2, 1960.

59. Ballis, p. 2.

60. State of California *Water Code*, paragraph 10505 and 11460-63 guarantee to counties and areas of origin first priority upon waters originating within their borders.

61. Letter to Lloyd Lowrey, Jr. from Lloyd Lowrey, Sr.

62. Los Angeles *Times* June 18, 1959, p. 2, c.7.

63. Telephone interview with Assemblywoman Pauline Davis, Palo Alto-Sacramento, January 21, 1971.

64. Cooper, p. 207.

65. Banks Interview.

66. Interview with Senator Clark Bradley, San Jose, California, December 10, 1970.

67. State of California Senate Bill 1106, pp. 2-3, 7-8. Now, Water Code paragraphs 12933, 12939-942.

68. See California Senate Journal, 1959 Reg. Sess., p. 2940; California Assembly Journal, 1959 Reg. Sess. p. 5658.

69. Stats. 1959, c. 2128; Water Code paragraphs 12627.3 and 12627.4. To date, the statute seems to have been largely forgotten.

70. California Senate Bill 1106, as introduced, March 31, 1959.

71. California Senate Bill 1106, as amended, May 28, 1959, p. 2, lines 21-24. Now, Water Code paragraph 12931.

72. Edmund G. Brown, Letter to Lloyd Lowrey, Jr., March 2, 1971. Hereinafter referred to as Brown Letter.

73. California Assembly Journal, *Appendix*, 1959 Reg. Sess., p. 6168.

74. Interview with Senator Hugh Burns, Sacramento, California, December 9, 1970.

75. California Assembly Journal, 1959, Reg. Sess. pp. 5645-5675.

76. Ballis, p. 4.

77. Interview with Lloyd Lowrey, Sr., Rumsey, California, September 21, 1970.

78. Letter from Judge George G. Crawford to Lloyd W. Lowrey, Jr., July 2, 1971.

79. Brown Letter.

80. Edmund G. Brown, *Reagan and Reality*, (New York: Praeger Publishers), 1970, p. 183.

81. Telephone interview with Thomas Mellon, Palo Alto-San Francisco, California, December 22, 1970.

82. Cooper, see generally pp. 228-240.

83. *Ibid.*

84. New York *Times*, Sunday, November 13, 1960, Sec. 3, p. 1., c. 5; San Francisco *Chronicle*, Friday, November 4, 1960, p. 1, c. 4

85. San Jose *Mercury*, Wednesday, July 27, 1960.

86. Cooper, pp. 235-236.

87. *Business Digest*, April 1968, San Francisco, p. 19; Cooper, p. 236.

88. Graham, p. 58, footnote 195. The final margin, expressed as a ratio, was 1.06 – 1.0 compared with a 1.1 – 1.0 margin for the 1933 vote on the Central Valley Project.

89. Lowrey Interview.

90. Some right-of-way acquisition and construction had started in 1959.

91. Fisher, p. 119.

92. Brown, p. 184.

93. Cooper, p. 246.

94. Cooper, p. 247.

95. See note 60, *supra.*

96. Letter from Russell Kletzing, Assistant Chief Counsel, Department of Water Resources, to Lloyd Lowrey, Jr., June 29, 1971.

97. Interview with J. R. Eaton, Chief of Water Project Analysis Branch of the Department of Water Resources, Sacramento, California, March 24, 1971. The surplus water may also be used for municipal and industrial purposes, but agriculture generally has first call.

98. Cooper, p. 278. California Department of Water Resources, *Bulletin No. 132-70: Appendix C – The California State Water Project Summary, 1969*, p. 7.

99. David Seckler, *California Water: A Strategy*, (Sacramento, California: Planning and Conservation League), 1970.

100. *Bulletin No. 160-70*, p. 41.

101. The Department of Water Resources published *Bulletin No. 160-66: Implementation of the California Water Plan*, relating the water project's progress to date and laying out plans for future accomplishments. Developments from 1956 – 1966 essentially confirmed the findings of *Bulletin No. 3*, with regard to water needs. The Summary and Conclusions of *Bulletin 160-66* are at pages 137-43 of that publication. Plans for North Coast Development are laid out at pp. 109-113.

102. Ironically, Brown attributes his defeat in part to his firm support of the Feather River Project. Brown, p. 183-184.

103. Remarks of state Senator George Miller, Jr., in *Testimony, Sacramento-San Joaquin Delta Hearings, Peripheral Canal*, (Martinez, California: Zardonella Reporting Service), February 17, 1967. Hereinafter referred to as Zardonella Testimony.

104. The Contra Costa County Water District has contracted with the Department of Water Resources, apparently, at least in part, to gain the DWR's goodwill. The CCCWD wants the Kellogg Unit, a Federal water development project, to be built – and was willing apparently to cooperate with the DWR in the hope that cooperation would be rewarded by DWR support of Kellogg. See the testimony of Mr. John DeVito in Zardonella, *Testimony*, p. 98.

105. Federal Water Pollution Control Administration, *Effects of the San Joaquin Master Drain on Water Quality of the San Francisco Bay and Delta.* January, 1967.

106. The U.S. Bureau of Reclamation is currently studying the need for such substitute supplies according to a letter to Lloyd Lowrey, Jr. from Mr. R. J. Pafford, Jr., Regional Director, U.S.B.R., April 30, 1969.

107. Letter from William Gianelli to Congressman Robert Leggett, May 7, 1969.

108. *Hearings. The Nation's Estuaries . . .*, Part 1, pp. 36-38.

109. The State of California, The Resources Agency, *Delta Fish and Wildlife Protection Study, Report No. 7: Water Development and the Delta Environment*, p. 18.

110. In the Winter 1969-70 issue of *Cry California*, Bob Simmons writes of the State Water Project's problems with unfavorable reports from the Department of Fish and Game. He calls Mr. Gianelli's response "not subtle" and tells of resignations and relocations within the Department as a result of pressure by Mr. Gianelli. Commenting on these allegations in a letter to Lloyd Lowrey, Jr., May 5, 1971, Mr. Gianelli wrote, "Frankly, the Department's position is not so intertwined with political intrigue as you seem to believe . . ."

111. U.S. Geological Survey Circular 637-A, B. *A Preliminary Study of the Effects of Water Circulation in the San Francisco Bay Estuary*.

112. State of California, Department of Water Resources, *News Release*, July 7, 1970.

113. *Bulletin 160-70*, pp. 88-91.

114. William U'Ren, "Liability Under the Water Supply (Delivery) Contracts of California State Water Project," October 1970, unpublished paper on file in the Stanford Law Library.

115. "$54 million will be spent for State Water Project recreation facilities and $6 million for fish and wildlife enhancement." *Bulletin 160-70*, p. 53.

116. The Metropolitan Water District, Letter from General Manager Henry J. Mills to the Board of Directors, dated October 8, 1970.

117. *Ibid.*, p. 3.

118. The Metropolitan Water District, Letter from General Manager Henry J. Mills to the Board of Directors, dated October 8, 1970.

119. *Ibid.*, p. 8.

120. Statement of William Gianelli to the California Assembly, Water Committee, February 9, 1970, p. 14.

121. See generally, Cunningham, p. 209.

122. *Bulletin 160-70*, p. 155-156.

123. Harding, p. 33.

124. Harding, p. 36.

125. F. Trelease, *Water Law Cases and Materials*, (West Publishing Co.), 1967, p. 24.

126. Harding, p. 37.

127. *Lux v. Haggin*, 69 Cal. 255 (1886); *Herminghaus v. Southern California Edison Company*, 200 Cal. 81 (1927).

128. Now part of the California Constitution, Article XIV, section 3.

129. The Porter-Cologne Water Quality Control Act became law on January 1, 1970, and amended Division 7, paragraph 13050, of the California Water Code.

130. See, e.g., the statement of Mr. Justice Shaw in *Miller v. Bay Cities Water Co.*, 157 Cal. 256, 107 P. 115, 128, as quoted in *Joslin v. Marin Municipal Water District*, 67 Cal. 2d 132, 429 P. 2d 889, 894. "In many parts of the state, especially in the large interior valleys, practically all the flood waters are waste waters. They contribute little or

nothing to the saturation of any subterranean gravel beds which are resorted to for a supply of water for useful purposes. They rush in great volume to the sea, carrying destruction in their path and overflowing the low lands to the great damage of the owners, serving no useful purpose. The extreme floods and consequent overflow and destruction would be prevented; the stored water could be used to irrigate large areas of the valley land, now left unproductive for lack of water; if distributed upon the plains, for irrigation, a large portion of these waters would in due course of time find their way by seepage and percolation to the channels of the streams . . .; all of which would add tremendously to the growth, prosperity and wealth of the state and to its ability to support the large population which its climate and productions attract. The question of the right to store such flood waters and the terms upon which it can be obtained or exercised is of the greatest importance to the future welfare of the state . . . These observations are self-evident, not only under present conditions, but for all time to come. *It requires no extraordinary foresight to envision the great and increasing population of the state and its further agricultural and industrial enterprises dependent upon stored water – water that is now wasted to the sea and lost to any beneficial use.* The conservation of other natural resources is of importance but the conservation of the waters of the state is of transcendent importance. Its waters are the very life blood of its existence." (Emphasis added)

Chapter Three

WATER RESOURCES IN THE SAN FRANCISCO BAY-DELTA REGION

The San Francisco Bay region has had an interesting past in its quest for water resources. The Bay Area is not a closed hydrologic system, either from a natural or man-oriented point of view. Water comes from the air, from surface sources, and from under the ground. Human society adds complexity by importing water from mountain regions and shipping waste water into the San Francisco Bay and the Pacific Ocean.

I. Water Supply Districts

Hetch Hetchy Aqueduct, under the control of the *San Francisco Water Department* (SFWD), was not the only aqueduct constructed by water suppliers. Barely had the initial controversy quieted down before the *East Bay Municipal Utilities District* (EBMUD) sought authorization and funds from the people to build the Mokelumne Aqueduct, drawing water from the headwaters of the Mokelumne River in the high country of the Sierra Nevada Mountains. These two huge water transport systems make the San Francisco Water Department and the East Bay Municipal Utilities District the veritable water giants of the Bay Area (See Fig. 2-2). Between them they supply a sizable percentage of the water needed by the region's people and industry. They achieve this both directly and through subsidiary distributors.

Water in San Mateo County, which is immediately south of the City & County of San Francisco, is delivered primarily by the *North Coast County Water District* and the *Coastside County Water District*. While there are nearly 30 more municipal and district suppliers in the county, most of the water distributed there is purchased from the SFWD – it is Hetch Hetchy water. Santa Clara County, the southernmost county on the San Francisco Peninsula, has almost as complicated a water supply picture as San Mateo County. The major water purveyor there, however, is the *Santa Clara County Flood Control and Water District* (SCCFC&WD), which draws water not only from the Hetch Hetchy Aqueduct, through the SFWD, and local ground water sources, but also from the State Water Project's South Bay Aqueduct.

The *Contra Costa County Water District* (CCCWD), one of the three major East Bay water suppliers in addition to the EBMUD, presents a different picture from other water agencies in the Bay Area, both in terms of the origin of its present supply and its plans for the future. Most of the District's water comes from the fresh water flowing into and through the Sacramento-San Joaquin Delta and the fresh water Contra Costa Canal, operated by the U.S. Bureau of Reclamation. They are presently taking a hard look at water reclamation for meeting future water needs. The other major East Bay supplier is the *Alameda County Water District* which probably utilizes more different water sources than any other water district in the area: aqueducts, water, ground water, ground water recharge, and water impounded in reservoirs.

To the north of San Francisco lies Marin County, with its gently rolling hills and picturesque towns. Its total population is relatively small, and its water needs little. These are therefore met quite well through ground water delivered by the *Marin Municipal Water District* and the *North Marin County Water District*.

Each of these 9 major water supply districts reflects varying philosophies toward water distribution and use. They each present different justifications for delivering the type of water they do, and they display a variety of outlooks toward the future – continued aqueductal transport, desalination, or reclamation.

A. San Francisco Water Department

In size, service population, and influence the San Francisco Water Department (SFWD) is the most important water supply district in the Bay Area. Without the water supplied by the Department, urban and suburban development in San Francisco and the San Francisco Peninsula would not have been possible. Presently 230 million gallons per day (mgd) are delivered to 2 million customers in San Francisco, San Mateo, Santa Clara, and Alameda counties. In order to obtain a better idea of their importance, we shall view the SFWD's development from an historical vantage point.

1. History of Hetch Hetchy

In 1901, the city engineer recommended that San Francisco develop the Tuolumne River system. This soon became known as the Hetch Hetchy project (1). This mammoth undertaking proposed to move Sierra water a distance of 149 miles west to San Francisco. John Muir led the fledgling Sierra Club and other conservationists in a heated and lengthy battle with the city, because the project included plans to build a reservoir within the boundaries of Yosemite National Park (2). Also involved in opposition were rival water districts and corporate interests who were against the idea of municipal utilities (3).

After 6 years of fighting, the Department of the Interior finally granted the necessary permit in 1907. That year, and 3 years subsequently, the City passed two bond issues totaling $45,600,000. At this point, the Department of the Interior revoked portions of the original development permit, so the City went to Congress, seeking legislation to revalidate their rights. More debate ensued, resulting in the passage of the Raker Act in 1913, which reinstated San Francisco as the trustee of Hetch Hetchy.

During the years 1907 through 1909, the city of San Francisco was hardly inactive. They had instituted acquisition of land and water rights at Hetch Hetchy, the Cherry Basin, and Lake Eleanor. The

mayor, in his capacity as a private citizen, filled out applications in his own name, generating further publicity (4). Not only was the city preparing its legal avenues, but it was also beginning construction of requisite roads, bridges, canals, and construction camps.

With the Hetch Hetchy development solidly underway, the City moved to acquire the entire water system. In 1930, the San Francisco Water Department took over the operation of the Spring Valley Water Co., the funds for this acquisition having been obtained from a $41,000,000 bond issue. During this same period, voters passed a $24,000,000 bond issue to finance the construction of the Coast Range tunnels and the San Joaquin pipeline.

The Hetch Hetchy project ultimately involved development of three water systems in the Sierras: Eleanor Creek, Cherry River, and the Tuolumne River. Water is impounded by three dams. Eleanor Dam and reservoir is the smallest in the system, having a capacity of 8.8 billion gallons and a drainage of 79 square miles. It was completed in 1918. O'Shaughnessy Dam on the Tuolumne, which forms the Hetch Hetchy Reservoir and which has a capacity of 117.3 billion gallons and a drainage of 459 square miles, was completed in 1923 and further raised in 1938. Cherry Dam, the most recent addition to the development, forms Lake Lloyd, which has a capacity of 87.4 billion gallons and a watershed area of 114 square miles. Located about one mile from Eleanor Dam, it was completed in 1958.

The water from these reservoirs flows to the San Francisco Peninsula water system via the Pulgas Water Temple, where it enters Crystal Springs Reservoir.

In acquiring the Spring Valley Water Co. in 1930, San Francisco assumed the responsibility of serving a considerable area outside of the city, comprising the entire Peninsula and much of the East Bay south of San Lorenzo.

2. The Water Users Association

The suburban customers of the San Francisco Water Department (SFWD) now include 11 municipalities, 15 water purveying districts, and 4 investor-owned water utilities. (See table on next page.) The only suburban users of San Francisco water which supplement this source with local sources are the cities of Daly City, Colma, and San Bruno, and the Coastside County Water District. Those Peninsula agencies, cities, and special districts that buy water from SFWD have formed the San Francisco Bay Area Water Users Association, which has acted as the negotiating body between the water buyers and the SFWD since 1959 (6). The Association is dedicated primarily to protecting suburban water rights on the Peninsula. For instance, in June of 1969 the SFWD proposed to increase suburban water rates by 20%, decreasing rates within the city itself. The Association protested – the result has been a 15% increase across the board.

The Association believes that San Francisco is not necessarily the sole *owner* of the Hetch Hetchy project, but is rather the *trustee*.

3. The Peninsula Water Agency

Besides the Association, another group has been formed to protect Peninsula water interests – the

TABLE 3-1
Water Deliveries to Suburban Purveyors – 1965-1969
San Francisco Water Department

Purveyor	Water deliveries, million cubic feet Year ending June 30		Water deliveries, million gallons per day (mgd)	
	1965	1969	1965	1969
San Mateo County				
Belmont County Water District	127.5	161.5	2.5	3.2
Brisbane, City of	11.4	12.6	0.2	0.25
Burlingame, City of	201.9	216.2	4.0	4.3
California Water Service Company – Bear Gulch	81.2	130.6	1.6	2.6
California Water Service Company – Broadmoor	27.4	29.5	0.5	0.5
California Water Service Company – Menlo Park	201.3	166.1	4.0	3.3
California Water Service Company – Redwood City	30.7	30.3	0.6	0.6
California Water Service Company – San Carlos	157.1	195.9	3.1	3.9
California Water Service Company – San Mateo	498.1	571.5	9.9	11.4
California Water Service Company – South San Francisco	256.7	309.2	5.1	6.2
California Water Service Company – Woodside	74.6	61.7	1.5	1.2
Clyde Henry – Friendly Acres	25.8	26.6	0.5	0.5
Coastside County Water District	10.2	14.6	0.2	0.3
Cordilleras Mutual Water Association	0.4	0.3	0.01	0.01
Daly City, City of	14.6	91.1	0.3	1.8
Dimond Public Utility District	14.8	16.8	0.3	0.3
East Palo Alto County Water District	87.1	98.6	1.7	1.9
Estero Municipal Improvement District	6.0	47.0	0.1	0.9
Guadalupe Valley Municipal Improvement District	3.7	9.8	0.07	0.2
Hillsborough, Town of	116.2	129.6	1.3	2.6
Los Trancos County Water District	- -	1.4	- -	0.02
Menlo Park, City of	93.5	159.7	1.9	3.2
Millbrae, City of	99.4	135.9	1.9	2.7
North Coast County Water District	106.9	138.3	2.1	2.7
Palomar Park County Water District	2.6	1.7	0.05	0.01
Redwood City, City of	312.2	375.9	6.25	7.5
San Bruno, City of	97.2	119.0	1.9	2.4
San Francisco International Airport	53.0	77.5	1.1	1.5
Skyline County Water District	0.7	2.2	0.01	0.04
Westborough County Water District	7.8	17.7	0.15	0.3
Other deliveries in San Mateo County	148.1	44.0	3.0	0.9
San Mateo County Total	2868.1	3392.8	57.4	67.8
Santa Clara County				
Milpitas, City of	119.9	197.7	2.4	3.9
Mountain View, City of	148.5	260.0	3.0	5.2
Palo Alto, City of	604.9	738.5	12.1	14.7
Purissima Hills County Water District	23.4	38.1	0.48	0.8
Sunnyvale, City of	307.3	489.7	6.1	9.8
Other deliveries in Santa Clara County	68.1	110.7	1.4	2.3
Santa Clara County Total	1272.1	1834.7	25.5	36.7
Alameda County				
Alameda County Water District	80.6	154.8	1.6	3.1
Hayward, City of	492.1	613.1	9.3	12.3
Other deliveries in Alameda County	73.6	134.2	8.7	2.7
Alameda County Total	646.3	902.1	12.9	18.1
Total Water Deliveries to Suburban Purveyors	4786.5	6129.6	95.7	122.6

Adapted from Brown and Caldwell, *Water Rate Study*

Peninsula Water Agency — which is comprised of most of the cities in San Mateo county, the special water districts there, and the County of San Mateo. The purpose of this group is to prepare a master plan for water use and additional supplies during the future growth of San Mateo County. This association is only about a year old and has not yet formulated a plan. The SFWD can produce only 400 million gallons per day (mgd), a supply that the Peninsula Water Agency feels will only meet water needs until about 1990. Possible new sources will come from desalinization of sea water and from waste water reclamation. The South Bay Aqueduct, part of the State Water Project, may also become a new source, since there are presently indications that Southern California will need less water than originally planned by the Department of Water Resources. While under the assumptions behind *Bulletin 160-70* more water could be diverted into the South Bay Aqueduct, statements made during the summer of 1971 by William Gianelli cast doubt on this (7).

B. East Bay Municipal Utility District

Just as the SFWD has controlled the water supply system on the Peninsula, the East Bay Municipal Utility District (EBMUD) is the most important water supply agency in the East Bay. It provides a water supply and wastewater disposal system for the people and industries bounded by the cities of Oakland and Berkeley on the west, San Leandro on the south, and Walnut Creek on the east and Rodeo on the north. The population of this area is estimated at 1.16 million people. Besides domestic water uses, there are demands from several water-using industries, located in the East Bay, most notably in the Richmond area.

The East Bay is also a semi-arid region. Local drainage (Lake Chabot, Upper San Leandro, Lafayette, San Pablo, and Briones reservoirs) provides only about 10 to 15 mgd. The decision to increase the water supply by an importation system was reached many years ago. Using the same strategy as San Francisco, EBMUD turned to the Sierras for more water. In 1923, a bond issue was passed to construct a system to bring water from the Mokelumne River. Water from the Sierra snowpack is impounded in Pardee Reservoir, which is located in Amador and Calaveras counties. Below Pardee Reservoir is Camanche Reservoir, which is used for flood control. The water is transported from Pardee 90 miles across the state to the East Bay in three aqueducts.

1. The Mokelumne System and Reserves

The capacity of the Mokelumne system is about 325 mgd, so the total amount of water available to the East Bay is about 335-340 mgd (8). Much like the Hetch Hetchy project of the SFWD, this imported water supply has made possible the development of the East Bay as an urban and industrial center.

Unlike the water agencies on the Peninsula, EBMUD is threatened with a water shortage problem in the near future. Peak water use during the summer of 1970 was just under 340 mgd, leaving no safety cushion of water supply in case of an emergency, such as a fire, or rupturing of a pipeline. This fact, combined with predictions of increasing population and increasing per capita consumption, resulted in the decision to get more water. There were very few choices: desalinization, reclamation, or another aqueductal

system. EBMUD has opted for the last choice, reasoning that they are fulfilling a mandate from the people, expressed with the passage of the 1923 bond issue, which financed the Mokelumne project (9). It is highly doubtful that desalinization and reclamation were even seriously considered.

2. Relations with the U.S. Bureau of Reclamation

The source of this water will be the Federal Bureau of Reclamation's Auburn Dam project, now under construction on the American River. Water will be taken from the Bureau's Auburn-Folsom South Canal. Although the route for the aqueduct system has not been chosen, it is likely to parallel the existing EBMUD aqueducts, in order to reduce litigation on the rights-of-way (10).

In December 1970, EBMUD signed a contract to buy water from the Bureau of Reclamation, marking the first time that EBMUD had agreed to buy water from another agency. The contract makes EBMUD one of the first municipal and industrial users of the USBR water. Up to 134 mgd of high quality water, over and above the present supply of 340 mgd from the Mokelumne Aqueduct and local sources, will thus be delivered to the East Bay.

According to EBMUD's population projections (See figure 3-1), the demand will exceed the present water supply by 1980. Since it takes about 10 years to go from the initial planning stage of an import system to the actual delivery of the water, EBMUD is relieved that the contract with the Bureau of Reclamation was consummated just in time (11).

The additional water from the American River will raise the total available supply of water from all sources to more than 460 mgd. This, according to EBMUD, is sufficient to satisfy projected demands past the year 2000 (12) (See figure 3-1). By the turn of the century, it is assumed that either desalinization or waste water reclamation will provide a viable economic alternative to the present transport systems.

Besides this projected increase in population, per capita water use is also expected to increase. In 1969, average use was 177 gallons per person, per day (this figure includes commercial and industrial users. Last year it had increased to 190 gal/cap/day. Some of this increase, but not all according to EBMUD, is due to the warmer, drier weather of the past year as compared to 1969 (13). Per capita use is expected to reach 200 gal/cap/day in the near future.

Heavy water use by certain industries is the primary reason for this high figure. Standard Oil uses about 25 mgd, 11% of EBMUD's supply of about 220 mgd. When industrial use is not included, the per capita use figure is about 115 gal/cap/day. (Even this figure varies within the district. In west Oakland, use averages about 90 gal/cap/day while in the western portion of the district the figure is closer to 130 gal/cap/day.

C. San Mateo County

Unlike the City and County of San Francisco, which has one water distributor, there are more than 30 cities and water districts which distribute water in San Mateo County. Almost all of the water, however, comes from the SFWD. The North Coast County Water District supplements water from SFWD with a

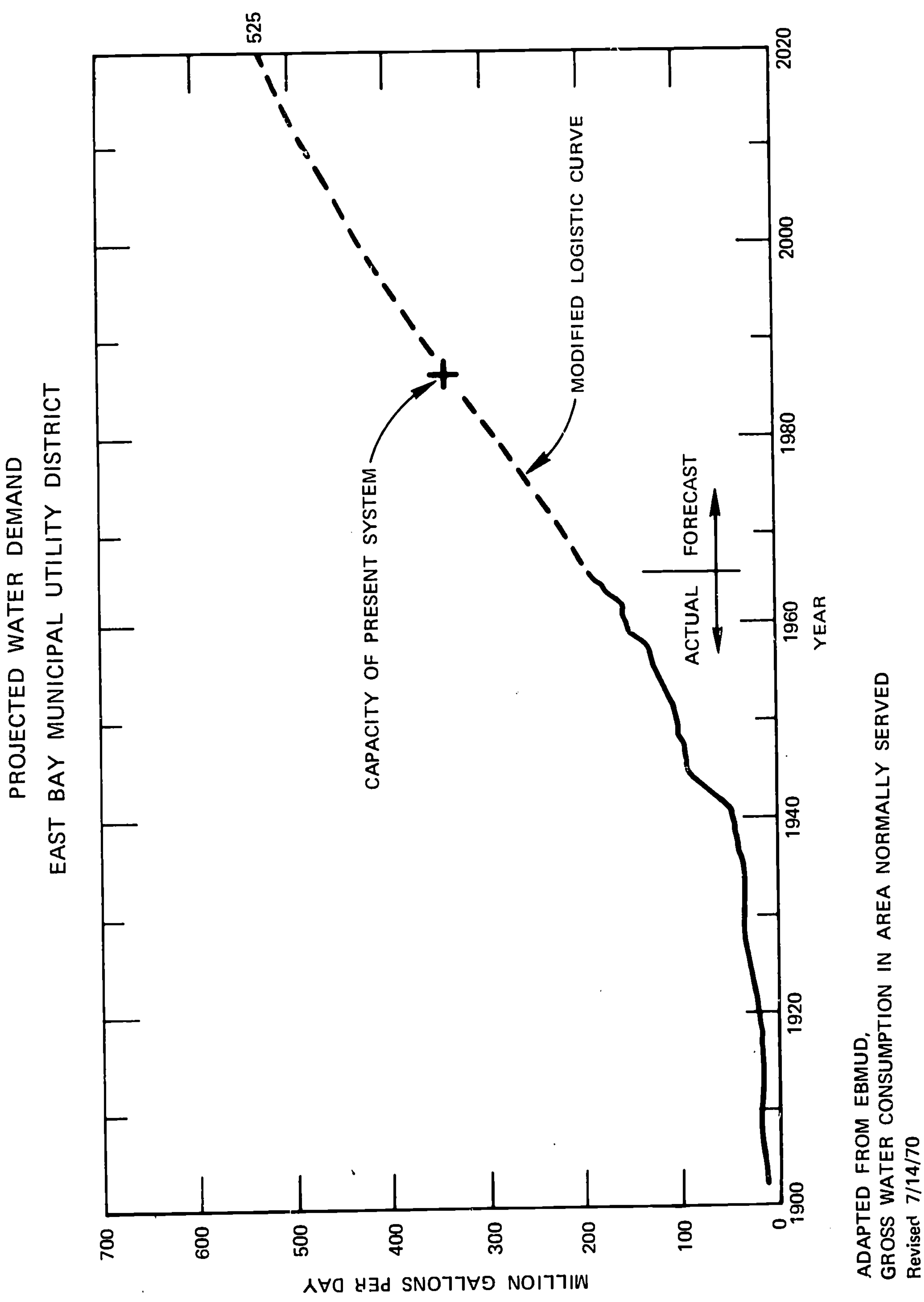

PROJECTED WATER DEMAND
EAST BAY MUNICIPAL UTILITY DISTRICT
CAPACITY OF PRESENT SYSTEM
MODIFIED LOGISTIC CURVE
525
ACTUAL
FORECAST
MILLION GALLONS PER DAY
700
600
500
400
300
200
100
0
1900
1920
1940
1960
1980
2000
2020
YEAR
ADAPTED FROM EBMUD,
GROSS WATER CONSUMPTION IN AREA NORMALLY SERVED
Revised 7/14/70

Figure 3-1

supply from San Pedro Creek. The city of Daly City gets 65% of its water supply from groundwater, the remaining 35% from SFWD. Also, the cities of Colma and San Bruno use groundwater sources. Finally, the Coastside County Water District, which services the Half Moon Bay area, currently receives 50% of its water supply from the SFWD Pilarcito Lake, the other half of the 1 mgd supply coming from local wells.

Since 1966, suburban water use from SFWD has exceeded use within San Francisco itself. At present, annual water deliveries to the suburban area comprise about 60% of the total water deliveries. This percentage will no doubt increase in future years, as there is more potential for growth in suburban regions of the Bay area than there is within the city. A study made for the SFWD projects increasing water use in the following proportions for the counties that use SFWD water:

Table 3-2*

Percentage Increases of Water Use in the Suburbs of San Francisco

County	1970 Water Use (mgd)	2000 Water Use (mgd)	Net Increase (mgd)	% Increase
San Francisco	103.6	131.8	28.2	27.2
San Mateo	85.6	166.5	80.9	94.5
Santa Clara	49.2	83.6	34.4	69.9
Alameda	315.5	53.3	21.8	62.2
TOTAL	269.9	435.5	165.3	61.6

*Table adapted from Brown and Caldwell, *Water Rate Study*, Table 3-1

As can be seen from this table, while the total water use will increase by 61.6%, the increase in San Mateo County is projected to be 94.5%. An interesting case in point in San Mateo County is the coastside area – land which at present is the least developed in the county, and unfortunately, the most likely to be developed.

1. Coastside County Water District

The Coastside County Water District is one of the smallest districts in San Mateo County, with a service area of 12 square miles and population of about 7700 people. Last year, average use was about 1 mgd, approximately half of which came from SFWD, the rest from local sources. Per capita use in this area is lower than the Bay Area average, less than 100 gal/cap/day. Apparently this rate is low because of the coastal fog, which reduces the need for daily watering, and other consumption.

Until recently, the Coastside County Water District had a contract with the SFWD for a maximum supply of 1 mgd. But during January 1971 a new contract was established, providing up to 10 mgd until

1990. Besides this increment, a local project on Dennison Creek is under construction. When it begins operation in about a year (February 1972), it will provide 1.5 mgd, thereby more than doubling the present supply.

This much increased water supply makes possible substantial population growth on the coast of San Mateo County. This is attested to in the projected water demands formulated by Kennedy Engineers of San Francisco, and listed below.

Table 3-3

Coastside County Water District*
Projected Water Demand

Year	Population	Demand (mgd)	District Supply	San Francisco Supplement
1970	7,700	1.0	0.2	0.8
1975	24,600	3.2	0.2	3.0
1980	42,300	5.5	0.2	5.3
1985	60,000	7.8	0.2	7.6
1990	78,700	10.2	0.2	10.0

* Adapted from Projected Water Demands, Coastside County Water District, Kennedy Engineers

In conjunction with projected increases in population, the Coastside District is assuming that its service area will grow in size to include most of the south coastal county from SFWD property westward. There is also an assumption that per capita use will increase steadily, reaching 130 gal/cap/day by 1995.

How are these assumptions and predictions determined? Population growth is not an independent variable, increasing at an endogenous rate. The number of people living within an area results from many complex interactions of such factors as job availability, transportation, cost of living, attitudes concerning land use and the availability of basic resources such as food, air and water. Coastside San Mateo county is a classic example of the determination of land use factors and processes in action.

There is, of course, no easy solution. Conservationists argue that the area should be left as open space for the benefit of all the people, rather than be developed for the benefit of a few. This attitude seems to have been instrumental in sending back to the drawing board the Army Corps of Engineers' plan for a dam on Pescadero Creek. (It is interesting to note that the main justification for the Pescadero Dam was to supply a municipal water supply to a projected coastside population of 150,000 by 2020. Since then population projections have been downgraded. The reason given for the necessity of the dam was that the Coastside District would not get any more water from SFWD. In fact, there were rumors that the existing contract would not even be renewed. Since the decision to reassess the Pescadero project in July, 1970, the water situation has drastically changed because of the new contract with SFWD.) Problems still remain, however, with the open space proposals.

Many people in the Bay Area would like to see coastside San Mateo County left relatively undeveloped because it is used for recreation purposes by the entire Bay Area. Yet at the same time, zoning laws and taxes are making it increasingly difficult for landowners on the coast, most notably the farmers, to continue to leave their land undeveloped. The general opinion expressed by the people living on the coast is that if the rest of the county wants the coast to be left undeveloped for recreational and aesthetic benefits, everyone should help pay the costs. Suggestions for a county-wide recreation tax have been proposed, to spread the burden.

D. Santa Clara County

There are over 20 agencies in Santa Clara County that purvey water. Most of these, however, are quite small and do not need to be discussed in this paper. The most important water supply agency in the county is the Santa Clara County Flood Control and Water District (SCCFC&WA). This agency has the responsibility for the conservation of local resources, reduction of flood hazards, and provision of an adequate water supply for all of Santa Clara County. The SCCFC&WD has been in existence since March 1968 when it was formed by the consolidation of the Santa Clara Valley Water Conservation District (organized in 1929) and an agency also named the Santa Clara County Flood Control and Water District (formed in 1951).

1. Santa Clara County Flood Control and Water District.

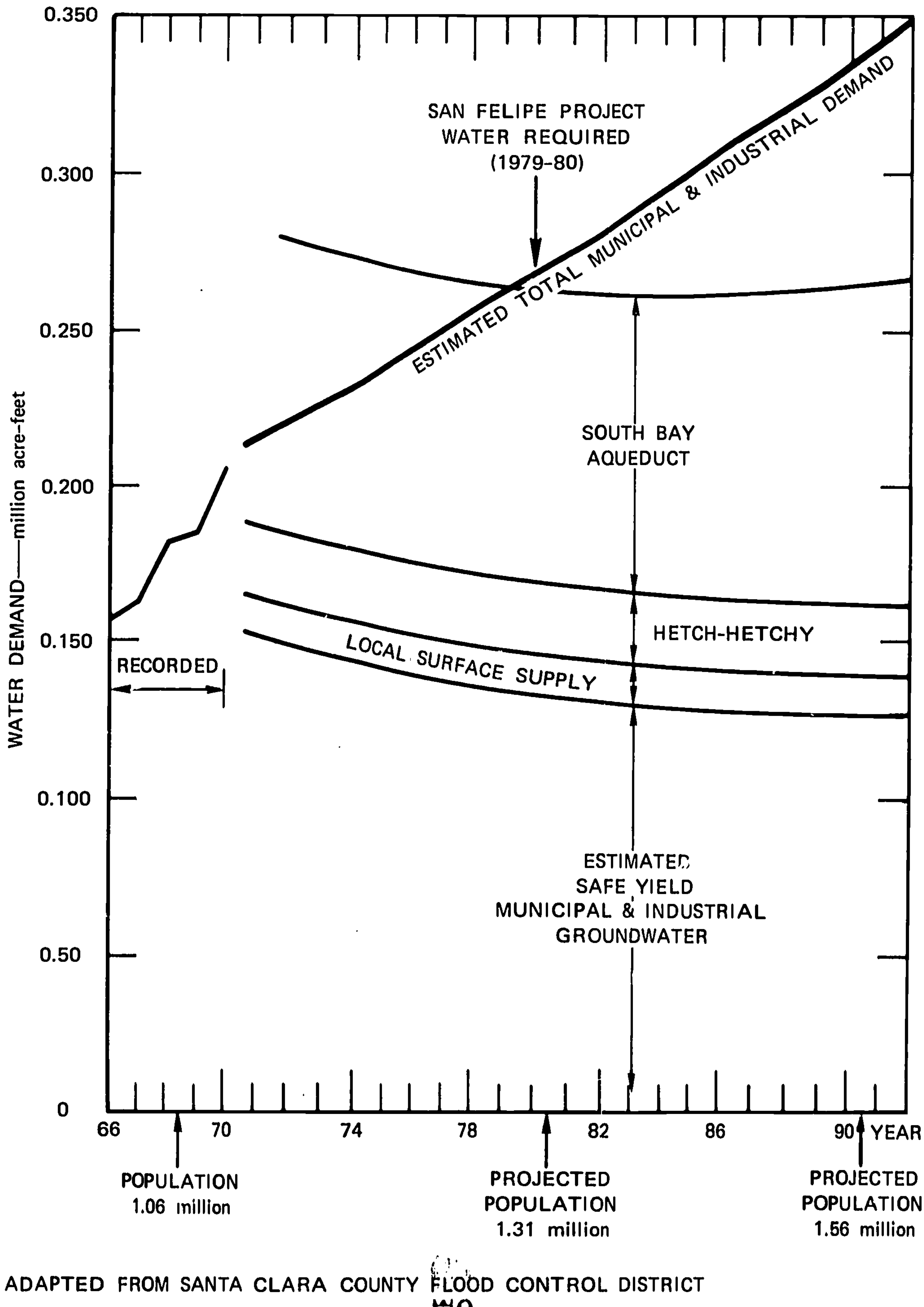
Figure 3-2 illustrates the complexity of present and future water supplies for the District. Water is received from a variety of sources; groundwater is presently the most important supply. This is supplemented by local surface drainage, water purchased from Hetch Hetchy, and water imported through the South Bay Aqueduct. In 1969, average use was 170 mgd. About 135 mgd came from groundwater sources, the rest from surface runoff and Hetch Hetchy. The water from the South Bay Aqueduct is harder to compute, though, since it is used mostly to recharge the groundwater supply. For instance, about 60 mgd of water from the Aqueduct were used to recharge the underground aquifers.

The District's main problem is maintaining adequate protection for their underground sources, much as in the case with Alameda county. During the last several years, groundwater supply has been depleted, resulting in subsidence of land and salt water intrusion into the aquifers. In order to combat this problem, an adequate level of high quality water must be maintained in the aquifer.

There are two different ways to recharge the underground supply: percolation and injection. At the moment, percolation is the most feasible because water used for recharge does not need to be of the same quality as the supply water itself. The reason for this is that as water is slowly percolated through sandy soils, many impurities are taken out of the water. By the time it reaches the underground supply, the quality of the water is extremely high. So water from the South Bay Aqueduct can be used for percolation recharge without any treatment.

There are several problems with this method, though. First, only land with certain soil characteristics can be used for percolation ponds, and this type of soil is very limited. The District presently has about 450

MUNICIPAL and INDUSTRIAL USE
SANTA CLARA COUNTY FLOOD CONTROL DISTRICT



ADAPTED FROM SANTA CLARA COUNTY FLOOD CONTROL DISTRICT

Figure 3-2

acres of land to use as groundwater recharge basins (15). 330 acres of this land is a surface water area. The rate of infiltration from the ponds into the ground averages about one foot per day on the net water surface area. For at least one month during the year the ponds are generally closed for maintenance. These facts point to the second problem: recharge by percolation is slow. Given limited land for use as recharge basins and the slow rate of percolation, it is obvious that recharge by percolation cannot meet the demand to maintain the groundwater supply which is continually more heavily drawn upon.

The other possibility is to recharge by injection. Injection, or direct pumping of water into the underground supply, bypasses the need for large areas of water surface and associated land and maintenance costs. But injection has problems equally serious. The most serious problem is that injected water must be of a quality at least as high as the receiving water. This is a major obstacle to large-scale use of injection, as there is no percolation through the ground to improve the quality.

What are future sources of water for the SCCFC&WD? The San Felipe Project, which is part of the U.S. Bureau of Reclamation's Central Valley Project, is the most likely source. This aqueduct system will transport water from the San Luis Reservoir to Santa Clara County, as well as San Benito, Monterey, and Santa Cruz counties. Another source presently being studied is reclamation of waste water, which will be discussed in more detail in the next section.

2. Additional Water Suppliers.

In addition to the SCCFC&WD, there are several other moderately sized water districts. The City of Santa Clara Water Department provides water for 85,000 people, with an average use of 13.3 mgd. Ninety percent of this water comes from local wells, and is therefore hard water. The remaining 20 percent is purchased from the SCCFC&WD.

Other cities in Santa Clara County also have mixed hard and soft water supplies. This could provide a unique opportunity for designing epidemiological studies to further investigate the phenomena we discussed in Chapter One – the elevated incidence of vascular disease among soft water users and the higher sudden death rate among the same population.

The City of Sunnyvale has a service population of 101,000, which uses about 17.5 mgd (1969 figure). Water comes from local wells (hard), from the SFWD (soft), and from the Santa Clara County Flood Control and Water District. Mountain View, on the other hand, purchases all of its water – 9.5 mgd – from the San Francisco Water Department in order to meet the needs of its 53,000 people.

The City of Los Altos has a more complicated water distribution plan, but would probably lend itself exceptionally well to epidemiological studies. Two private companies deliver water: the California Water Company and the North Los Altos Water Company. Residents supplied by the former receive a mixture of aqueductal and well water. About 60 percent is imported via the South Bay Aqueduct while 40 percent is hard, well water. Those who receive their water from the North Los Altos Water Company, receive *exclusively* hard, well water. Since all other variables would be controlled, presumably, comparison of incidence and mortality rates of the diseases in question, in regions of the city receiving water of different hardness, could shed light on a very important medical problem.

E. Contra Costa County Water District

The Contra Costa County Water District (CCCWD) supplies water to the area encompassed by Walnut Creek on the west, Martinez on the northwest, and Antioch and Oakley to the east. This area is different from the others already discussed because of its heavy industrial use and because of the seasonal offshore water supply from the San Joaquin River. Presently, the District takes in 108,000 acres with an estimated population of 250,000 (1968 figure) (16). Where does the water for these people come from and what are future plans?

During the early decades of this century, water needs in Contra Costa County were met by groundwater supplies and by seasonal diversion of water from the Sacramento-San Joaquin River system. Seasonal diversion from Mallard Slough began in 1928. During high Delta outflow through these rivers in the winter and spring, there is an abundant offshore freshwater supply. During low outflow periods, especially during the summer, tidal action pumps salt water up the estuary and into the Delta. The distance that the salt water travels into the Delta depends on Delta outflow, which acts to flush out the saltwater. During summers of negligible outflow, salt water moved as far upstream as Stockton.

Seasonal diversion was therefore an undependable supply and the groundwater was not abundant. A system which would supply a reliable source of water was sought and the the Contra Costa Canal was conceived.

This canal diverts water from Rock Slough in the Delta (off of Old River), transporting the supply to a terminal reservoir in Martinez. Water was first delivered to the Pittsburg-Antioch area in 1940; completion of the canal to the terminus was accomplished in 1948 (17).

1. Contra Costa Canal

The Contra Costa Canal was designed to meet agricultural needs of the Diablo Valley and the Antioch-Pittsburg area (18). But this need never developed. Instead, Contra Costa County became the center of heavy industry in the Bay Area.

In 1968, use of the total canal – which is the source for all CCCWD water except offshore water – averaged about 90.5 mgd. A full 50% of this water was distributed to industries, 39% for municipal use, and only 5% for agriculture (19). Six per cent of the total supply was lost through seepage and leaks. In addition to canal water, offshore sources supplied 27.5 mgd in 1968 for municipal and industrial process water, so that about 23% of the total supply came from the offshore sources. In 1967, a wet year, this percentage was 44%. This variation in the offshore source reflects the prevailing hydrologic conditions in the Central Valley, which in turn largely determine the availability or extent of the period in which high water exists offshore (20).

The breakdown of water supply and use can best be shown in a table: (See page 56)

The enormous quantities of cooling water are used primarily by one industry: Pacific Gas and Electric. Most of the water is used only once; therefore, quality is not an important factor (21). However, because it is very important for some other uses, quality of off shore water for Contra Costa County has been a source of controversy for years.

Table 3-4*

Water Use from the Contra Costa Canal

Year	Municipal	Industrial	Agricultural	Unaccounted	Total Diversion
1965	(38%) 21.8 mgd	(54%) 31.0 mgd	4.4 mgd	5.5 mgd	62.7 mgd
1966	(40%) 29.4 mgd	(52%) 38.2 mgd	5.3 mgd	6.0 mgd	79.9 mgd
1967	(38%) 22.8 mgd	(54%) 32.4 mgd	4.2 mgd	2.6 mgd	62.0 mgd
1968	(41%) 33.8 mgd	(54%) 45.5 mgd	4.8 mgd	5.5 mgd	89.6 mgd
1969	(38%) 25.2 mgd	(51%) 33.8 mgd	3.9 mgd	3.0 mgd	65.9 mgd

* Adapted from CCCWD: The Delta Source of Supply for CCCWD, Table 4

Table 3-5*

Diversion from Offshore Supply
(Jersey Island to Martinez)
(mgd rounded)

Year	Municipal and Industrial Process Water	Industrial Cooling Water	Total
1965	45.0 mgd	1860 mgd	1905 mgd
1966	30.2 mgd	1960 mgd	1990 mgd
1967	49.4 mgd	2030 mgd	2079 mgd
1968	27.4 mgd	1870 mgd	1897 mgd
1969	46.5 mgd	1880 mgd	1927 mgd

* Adapted from CCCWD: The Delta Source of Supply for CCCWD, Table 5

2. Impact of State and Federal Water Projects

At the source of the problem is diversion by the State Water Project (SWP) and the Central Valley Project (CVP) of the Bureau of Reclamation. The SWP is designed to transport water from northern California to the San Joaquin Valley and population centers in the southern part of the State. The goal of CVP is to supply agricultural water in the Central Valley. In order to accomplish this task the water must either move through, or around, the Sacramento-San Joaquin Delta. Both of these methods can cause water quality difficulties in the Delta. At present water is being transported directly through the Delta waterways. State and federal pumping plants near Tracy, at the southern tip of the Delta, move the water south. With increased diversions south several problems are created. If too little water is flowing out of the Delta saline water will move into the Delta. Also, flow reversals in some of the many streams in the region can and are taking place, leading to confusion and death of migratory fish. (See Chapter Five)

3. The Peripheral Canal

A proposed Peripheral Canal has been put forth by the State Department of Water Resources and Federal Bureau of Reclamation as a solution to these problems. The Canal would divert water from the Sacramento River near Hood around the eastern side of the Delta feeding into the Tracy pumping plants (See fig. 3-3). Controlled releases into the eastern Delta would provide flow regulation and salinity control. The extent of salinity control in the western Delta and confluence area of the Sacramento and San Joaquin rivers depends upon the amount of water released. So the quality of offshore water depends largely on the quantity of outflow. A large outflow will provide a freshwater offshore supply for a greater part of the year than would a small outflow, for the latter would allow salt water to penetrate into the Delta.

The State has conceded to reimburse the water users for their loss of some of the offshore water supply due to salinity intrusion. However, several of the industries probably face serious economic problems due to increased water costs. A recent decision by the State Water Resources Control Board has helped to clear up some of the controversy over Delta water use (22). The Board stated that legal users of the water in the Delta have rights senior to both Department of Water Resources or Bureau of Reclamation, provided the uses conform to the constitutional policy of reasonableness (23). The rights of Delta water users, however, extend only to water quality and quantity which would have existed in the absence of the state and federal projects (24).

4. Central Valley Project

The District presently has a long term contract with the Bureau of Reclamation for 77 mgd from the Contra Costa Canal of the Central Valley Project. The contract expires in 1991. As can be seen in Table 3-4, this limit is exceeded in dry years, such as 1968 was. Negotiations have been going on since 1967 for an additional 97.5 mgd for CCCWD, which would bring the total supply from the Canal to about 175 mgd. But according to population projections this amount of water will meet District demands only until the early 1980's. (This estimate was derived from a report written in 1969. Since then, population projections

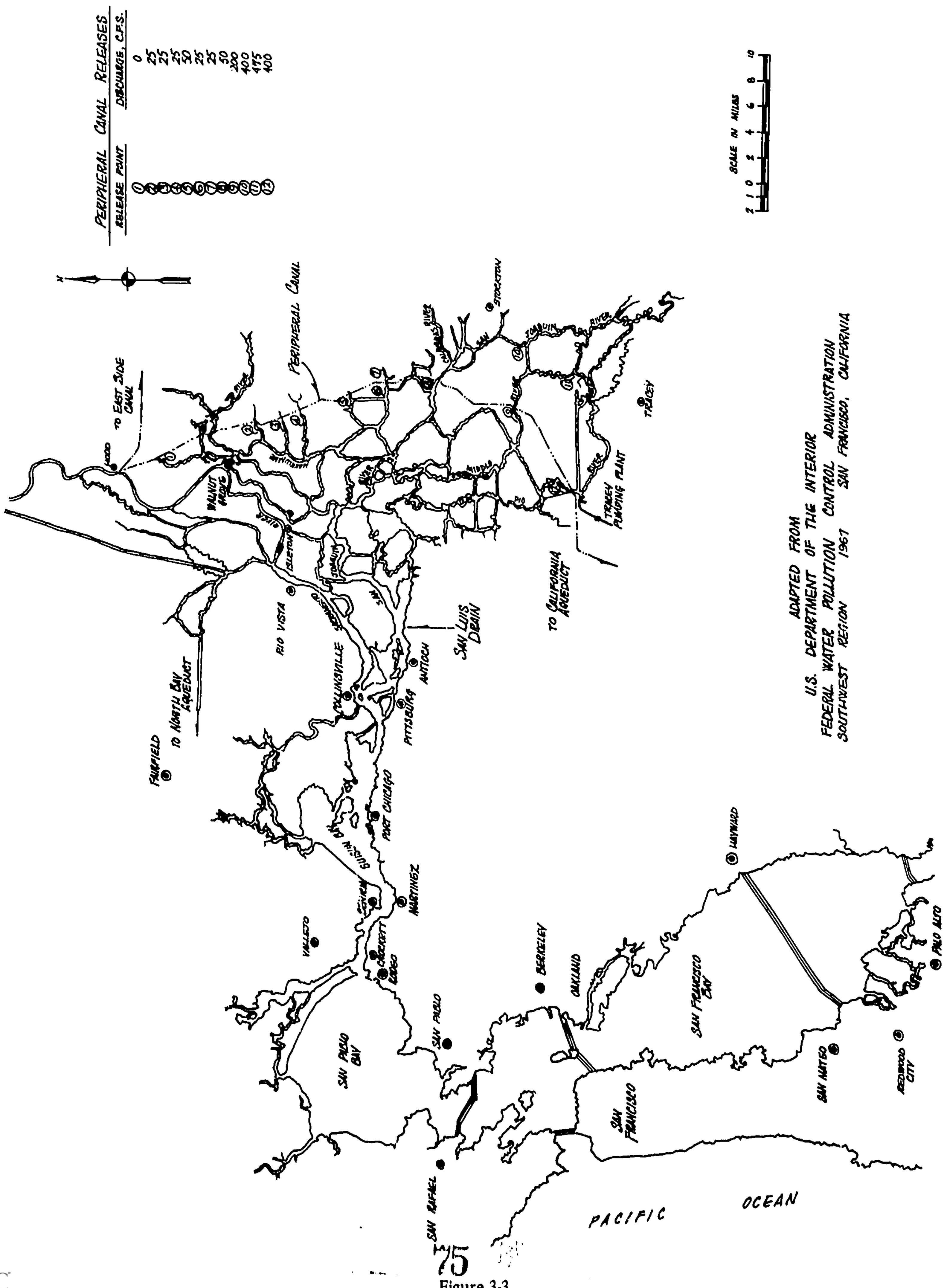

PERIPHERAL CANAL RELEASES
RELEASE POINT
DISCHARGE, C.F.S.
1 0
2 25
3 25
4 25
5 50
6 25
7 25
8 50
9 200
10 400
11 475
12 400
SCALE IN MILES
TO EAST SIDE CANAL
PERIPHERAL CANAL
STOCKTON
TRACEY
TRACEY PUMPING PLANT
TO CALIFORNIA AQUEDUCT
SAN LUIS DRAIN
RIO VISTA
ISLETON
WALNUT GROVE
HOOD
TO NORTH BAY AQUEDUCT
FAIRFIELD
COLLINSVILLE
PITTSBURG
ANTIOCH
PORT CHICAGO
MARTINEZ
VALLEJO
CROCKETT
RODEO
SAN PABLO BAY
SAN PABLO
BERKELEY
OAKLAND
SAN FRANCISCO BAY
HAYWARD
PALO ALTO
REDWOOD CITY
SAN MATEO
SAN FRANCISCO
SAN RAFAEL
PACIFIC OCEAN
ADAPTED FROM
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHWEST REGION 1967 SAN FRANCISCO, CALIFORNIA

Figure 3-3

have been downgraded somewhat, but it is still estimated that an additional 53 mgd will have to be generated by 1990.)

In order to augment its supply to meet future projected needs, CCCWD has several alternatives, although only two are presently considered feasible: surface water importation and reclamation.

5. Modified Kellogg Project

CCCWD is promoting a project known as the Modified Kellogg Project (25), to be built to satisfy surface water needs until 2020, when demand is expected to reach 400 mgd. The basic components of the project are the following: water from Clifton Court Forebay would be pumped through the State's Delta pumping plant, and withdrawn from the California Aqueduct immediately downstream from the discharge headwork of that plant, entering a proposed canal through a control structure. This water would then be fed by gravity to the Contra Loma reservoir in Antioch, and released into the Contra Costa Canal when needed. The Modified Kellogg Unit, like the Contra Costa Canal, is under the jurisdiction of the Bureau of Reclamation.

The CCCWD is presently the only water supply agency in the Bay Area which is running a pilot plant to test the feasibility of reclaiming waste water. CCCWD is working in conjunction with the Central Contra Costa Sanitation District (CCCSD) to produce reclaimed water economically. The CCCSD provides waste water disposal service to Central Contra Costa County; water supply for this area comes from both CCCWD (40%) and EBMUD (60%). Average summer waste water flow from the Sanitary District is about 18 mgd, the effluent being discharged into Suisun Bay. A pilot plant has been set up near Concord, with the goal of finding out the best method of reclamation. Reclamation is an attractive alternative in this area because there are several industries close to the pilot plant which could use the water for industrial processes (26).

This project will be discussed in more detail later in the report, for it provides a very interesting comparison with projects of the other agencies in the Bay Area. Why CCCWD is looking at reclamation as a source for its water and why other agencies are not will be explored later.

F. Alameda County Water District

Unlike San Mateo and Contra Costa counties, Alameda County has an abundant groundwater supply which is the major source of water for the Alameda County Water District. This District serves a 100-square mile area, mainly comprised of the cities of Newark, Fremont and Union City. About 155,000 people live in this area although this figure is expected to increase dramatically in the future.

ACWD was organized in 1914 with the purpose of protecting the underground water basin. Water supply for the District comes from a variety of sources and is more complicated than the situations for the districts already discussed because of the underground supply. Water is brought from the San Francisco Water Department's Hetch Hetchy system. The groundwater supply is recharged also with water from both the State Water Project's South Bay Aqueduct and the Del Valle Reservoir. Breakdown of the supplies for 1971 follows:

Table 3-6 (27)

Water Supply Sources, Alameda County

1971 CAPACITY			
Hetch Hetchy	11 mgd		
Groundwater	29 mgd	Recharge 22.8	– South Bay Aqueduct
Total capacity	40 mgd	14.6	– Del Valle Reservoir

Of this total capacity, use in 1970 averaged about 20 mgd, with individual use averaging 150 gal/cap/day. Water demands will increase greatly in the next twenty years, for it is predicted that by 1990 there will be some 400,000 people living in the service area. This growth is related to the availability of land to be developed. Evidently, agriculture is expected to be only a small fraction of its present size by 1990. (A comprehensive master plan has already been designed to accommodate this growth.)

Where will the additional water come from? The only detailed figures available show sources of supply only until 1975. These sources are given below:

Table 3-7 (28)

Water Supply Sources, Alameda County

1975 CAPACITY		
Hetch Hetchy	11 mgd	
Groundwater	39 mgd	Recharge – same as 1971
Treatment plant	10 mgd	Located in Mission San Jose
Total capacity	60 mgd	

About 22.4 mgd is estimated to be the local underground supply (as distinguished from the recharged underground supply). Most of it is not presently usable because it seeps into the upper aquifer, which is contaminated by salt water intrusion. This source will be explored by the District after 1975.

The Peripheral Canal is also an important issue in the Alameda County Water District. However, unlike Canal opponents in Contra Costa County, the ACWD enthusiastically supports the project (29). The reason for this is not hard to understand. The District receives high-quality water from the State's South Bay Aqueduct. Water from the Aqueduct is expensive ($26/AF compared to $4/AF for water from the Del Valle Reservoir). It is also low in hardness, unlike the local supply of the District. (In order to combat the hard water problem a 25 mgd water softening plant is being constructed to reduce hardness from its present value of 200-250 parts per million (PPM) to an average value of 85-100 ppm (30). The Peripheral Canal would transport Sacramento River water around the Delta to the pumping plants in Tracy, where the South Bay Aqueduct begins. A firmer supply of high quality water to the Aqueduct would be available through the Peripheral Canal than through the present system of transporting water through Delta channels where it picks up extra hardness. There are many other arguments pro and con concerning the Canal, but its effect on the South Bay Aqueduct seems to be the most important criteria as far as the Alameda County Water District is concerned.

G. Marin County

Water is distributed in Marin County by two agencies: the Marin Municipal Water District and the North Marin County Water District. These shall be discussed respectively below.

The Marin Municipal Water District services the southern part of Marin County from the Golden Gate bridge to Hamilton Air Force Base (not including the Pacific Coastal area), and west to San Geronimo. The population of this area is presently 160,000 people. Water use, which is almost exclusively municipal,averaged about 29 mgd in 1970. The supply of water comes from drainage and storage projects. There are five lakes in the district used to store local drainage (31).

Unlike the Peninsula, there is still plenty of room for land development in Marin County. It is planned that the water will come from the Russian River, by way of the Warm Springs Dam – a Corps of Engineers project. Water from this project will serve the Marin Municipal Water District, the North Marin County Water District, and agencies in Sonoma County. Completion of the project is expected within three to four years. The Marin Municipal Water District will receive an additional 35.8 mgd from Warm Springs Dam. This increase will more than double its present water supply. According to population projections, supply from these projects should be adequate until 1990 or 2000.

The North Marin County Water District supplies water for nothern Marin and Southern Solano counties. The present population of the area is estimated at 35,000 people. Water consumption averaged 5.25 mgd last year. A reservoir which captures and stores local drainage is the source of this water. The Warm Springs Dam project will increase this water supply to 10.7 mgd, which is projected to satisfy the needs for the estimated population until around 1990. The District predicts a 50,000 population by 1980,

and 70,000 by 1990. Predictions further show that the District will need an additional 2.7 mgd to provide an adequate supply until 1995 (32).

II. Population, Land Use, and Waste Water Policy

In the preceding sections we have attempted to describe the major components of the water supply systems in the Bay Area. The differences between the problems and plans among the different districts can provide interesting examples for analyzing water supply needs in relation to population growth, land use, and waste water policy.

The *total* cost of water use in any locale includes the cost of water supply and waste water disposal. These costs are essentially paid for by one group: the taxpayers. That is, those who are paying for water supply are generally the same ones who must pay for disposal of liquid wastes. The best solution to the water use problem, then, is the one which costs the least, taking into account costs for *both* water supply and waste disposal. This point of view, unfortunately, is not the basis for decisions by officials in the Bay Area. For one reason, most counties in the area handle the water supply system and the waste disposal system through separate agencies. (The East Bay Municipal Utility District is an exception, as we discussed earlier.) The water supply district usually looks only for the least-cost alternative to the water *supply* problem, while sanitary districts look only at *disposal* costs. It does not follow, however, that the sum of these two costs is the least cost for total water use. The reason for this is that water mixes with water.

Perhaps an example will help explain what is meant by water mixing with water. Suppose a water district should decide that the best alternative for water supply is a long distance aqueduct system from mountain streams. At the same time, the sanitary district finds it necessary to use secondary treatment for effective disposal of wastes. The costs of both of these systems are paid by the taxpayers. But perhaps if water use were to be looked upon as a single problem, incorporating both *input* and *output*, the least cost solution would include tertiary treatment of wastes to regenerate usable water, which would then be mixed with the existing supply.

A. Benefit-Cost Analysis

The basic concept used to figure out the best alternative solution to a water use problem is the benefit-cost analysis. A benefit-cost (b/c) study involves a comparison of all the costs of an alternative with all of its benefits. That alternative with the greatest ratio of benefits to costs is deemed the most favorable. In any b/c study, the *area* in which the benefits and costs will accrue needs to be defined. The danger inherent in rigid boundary-making lies in the possibility of inducing benefits which result in increased costs in another area, so that if a wider framework is used, no benefits result. For instance, transport of Sierra Water into the Bay Area will have some effect on the area of origin, even though this area is not subjected to a b/c analysis. So while looking at water use in the Bay Area, "outside" effects must be watched for. Another problem with a b/c analysis is the definition of *criteria* for benefits and costs. Traditional analyses have used only *monetary* gains and losses as a yardstick. In recent years it has become very evident that this

guideline is inadequate. Nonmonetary factors are often regarded as intangible, and therefore not measurable. If a factor cannot be measured, it is very difficult to use in a b/c analysis and therefore generally it is not considered seriously. In order to solve this problem wider criteria must be used in defining benefits and costs. Public health, aesthetics, and environmental quality are factors which are very difficult to quantify, but which are much too important to be glossed over. Proper analysis must consider all of these and grant relative weights to each of the factors. Of course, this should be explicitly stated in the analysis.

The calculation of a b/c ratio is only the first part of the task in solving problems. Cost allocation — deciding who is paying for the project — is at least as important, and it brings in many questions of equity and ethics. It is reasonable to assume that all water use costs are allocated in one way or another to the taxpayers in the Bay Area. This gives us a handle for internalizing more indirect costs and benefits. The problem is to find the least cost solution for water use.

B. Water Transport and Water Reclamation

One comparison which needs to be made is an analysis of increasing water supply via long distance transport vs. tertiary waste water reclamation. A benefit/cost comparison between these two methods of water supply systems may be easy to imagine but is extremely difficult to compute. The reasons for this are numerous. Most of the long distance transport projects were built over long periods of time and the money was made available through political processes rather than according to economic timetables. Therefore, no one really knows the true costs of these projects. Many benefits and costs are extremely difficult to compute or even to identify. For example, massive diversion from a river will probably have some effect on the aquatic life in that river, but quantification of the value of loss or gain may not be possible. Cost figures for reclamation are much more concrete even though they are changing very rapidly and important local factors make blanket figures difficult to use.

The Bay Area is in a fortunate position to make this comparison. The East Bay provides two good examples which should enable us to make some tentative conclusions about the relative merits of both of these methods. As was mentioned, the East Bay Municipal Utility District has recently signed a contract with the U.S. Bureau of Reclamation for 134 mgd (maximum), which will be taken from the American River via the USBR's Folsom South Canal. The actual distance this water will travel is not known, since the route has yet to be made public, but it will be a distance comparable to the existing aqueduct system which brings water from the Mokelumne River. The specific cost of the project is not certain either, but EBMUD estimates it to be about 300 million dollars (33). This includes costs of construction, land rights, operation, maintenance, and treatment. From a total water use perspective, however, this estimate does not include all costs. For instance, this increased water supply will result in increased waste water flows, and therefore increased treatment costs. Increased sewage will also create environmental problems. These costs will become especially pertinent when comparing EBMUD with its counterpart in Contra Costa County.

The CCCWD, like EBMUD, needs water now. But instead of planning for a long distance transport project (the water they now receive from the Contra Costa Canal travels about 46 miles from Rock Slough

to Martinez) they are considering reclamation as at least a partial solution. The CCCWD is operating a pilot treatment plant in conjunction with the Central Contra Costa Sanitary District in order to determine the most feasible solution to both the waste disposal and water supply problems. The plant, owned by the CCCSD, is located near major industrial and municipal water users (near Martinez). After detailed preliminary studies were done, CCCWD decided that: 1) it was technically feasible to reclaim water for irrigation and industrial purposes; 2) reclamation for municipal use still required extensive research; 3) the CCCSD Chenary treatment plant could be converted to a 5 to 10 mgd water renovation plant, producing water for industrial use; and 4) cooperation between CCCWD and CCCSD was the most promising way to attack problems of water supply and waste disposal (34).

Cost figures for water renovation vary from case to case, but they remain in the same range. One of the major cost variables is the distance of conveyance of water and waste water (35). Central Contra Costa County is fortunate because conveyance facilities for the waste water already exist and potential users of the renovated water are located primarily within two miles of the plant. Another important cost factor is the quality of the waste water. While one does not generally think of waste water as being of high or low quality, there actually are great differences. CCCSD waste water is of relatively high quality, largely because 60% of the effluent is used EBMUD water, which comes originally from the Mokelumne River and has very low mineral content. As far as most industrial processes are concerned, total dissolved solids (TDS) is the most important parameter. So again this area is fortunate to have a waste water that contains a rather low concentration of TDS).

There are still more reasons for considering municipal waste water as a source of supply. It is usually near the point of use and is in ample supply in most communities. It also has a relatively low level of contamination as compared with sea water. Finally, increasingly stringent water pollution control laws are requiring higher degrees of waste water treatment. Relatively small incremental costs may be all that is necessary to upgrade treatment plant effluents to a usable quality.

C. Waste Water Reclamation Cost

The Bechtel Corporation has done several studies on the costs of waste water renovation (36). The following figures are based on a hypothetical plant with a 30 mgd flow, located in southern California. A basic primary and secondary treatment plant would cost about \$10.3 million to build (capital costs) and 16.7¢/1000 gallons to operate (water costs). In order to generate low quality industrial and agricultural supply, by adding sand filters to the primary and secondary system, capital costs would increase by only \$3.2 million to \$13.5 million, while total water costs would be about 20.8¢/1000 gallons.

Further cost increments result in higher quality water, which can be put to more valuable use. For instance, adding activated carbon treatment, instead of sand filters, to the above system, would make capital costs total \$14.3 million and water costs total 22.3¢/1000 gallons. High quality industrial use is possible, as is ground water recharge.

Adding activated carbon adsorption, lime coagulation, and ammonia stipping to basic primary and

secondary waste water treatment, generates a potable supply, costing about $21 million in total capital costs for a 30 mgd plant and 36¢/1000 gallons to operate. The only quality factor which will increase with the treatment given in this case is the Total Dissolved Solids (TDS). With each cycle through the plant TDS increases. The only way to reduce the TDS concentration is through some demineralization process, such as distillation, reverse osmosis, or electrodialysis. The estimated cost for advanced tertiary treatment plus electrodialysis is $21.9 million, total capital costs, and 37.4¢/1000 gallons water cost.

These estimates, it should be realized, are high. First, water reclamation technology is in its infant stage, although it has made some significant improvements in the last few years. It is not unreasonable to expect that advances in technology will further reduce the cost of reclamation. Second, these estimates were based on a modular, incremental construction. Experts have stated that a reclamation plant designed initially for the purpose of renovating water of a specific quality could be constructed and operated for significantly less than a plant built by incremental design (37).

Neither of these factors exists in the case of long distance importation projects. Dam and aqueduct technology will probably not advance significantly in the future. Actually, costs can be expected to rise because the main cost factors, land and labor, will probably increase in the future. About the only decrease which could occur would be through equipment sharing with other large construction project developers such as highway contractors. This plan is included in the proposal for the Peripheral Canal.

The fact that reclamation projects are underway in several parts of the world (See Welsh, *et. al.* *Politics of Pollution Control in Monterey Bay* for examples at Lake Tahoe, in South Africa, and in Southern California.) is good evidence that under certain circumstances, reclamation is the most feasible alternative to solving the water use problem.

However, there must be *something* about importation projects which makes them seem favorable, since they remain popular with many water supply agencies, including EBMUD and the State's Department of Water Resources. Why has EBMUD chosen to continue to increase its water supply via an importation project?

D. Water Supply Districts vs. Sanitary Districts

It is interesting to note that water supply districts tend to be more conservative than sanitary districts. There is good reason for this. A water district needs to have a firm, long-term supply of good water. Therefore, their plans tend to look several decades into the future. In order to make plans for such a long period, water supply must be safe and consistent; water importation projects have proven themselves historically to be so.

EBMUD's firm policy is to deliver the highest quality water to its customers. This policy was initially set forth after the voters passed the 1923 bond issue which provided funds for the Mokelumne River project. It was decided that the American River project was the best solution to the water supply problem given the criteria of providing the best quality water available. However, as we discussed earlier, new medical data might change the conception of what constitutes "highest quality water."

In their annual report, EBMUD stated that alternative plans to increase the supply would include waste water reclamation and seawater distillation (38). This is undoubtedly so. But in interviews with several people from other water districts and engineering firms in the Bay Area, we received the impression that EBMUD did not seriously consider waste water reclamation a possible alternative.

Sanitary districts, on the other hand, tend to operate with a shorter time span in mind, usually 5 or 10 years. With this orientation, faster policy changes are possible; standards and methods can be changed to meet changing demands. Pollution control laws have changed dramatically in the last few years; the goal is to have all sewage put through a secondary treatment plant. This was undoubtedly a factor promoting the cooperation between CCCSD and CCCWD. As was shown, the incremental cost to generate usable water from secondary treatment is quite low.

Again, there seems to be a sort of paradox in EBMUD's situation. Unlike the districts in Contra Costa County, EBMUD handles not only water supply but also waste water disposal for its service population. Some 80 mgd of primary-treated effluent is discharged into the Bay, on either side of the Bay Bridge. Plans are underway to upgrade the plant to secondary treatment status; so about 35% of the water supply would be discharged as waste, even though, at small incremental costs, it could be developed for industrial use. Standard Oil, the largest water user in the district, has expressed interest in using a renovated water supply if one were available (39). The main problem would be transporting this renovated water to its point of use. Pipelines would have to move about 6 miles through a heavily urbanized area; conveyance costs would be very high. Even so, it might still prove economical to renovate a portion of the waste water for industrial use. We believe that EBMUD probably did not give this alternative serious consideration.

III. Population Growth

Other factors which must be studied carefully in any resource development project include land use and population projections. These have been discussed briefly in a previous section (Coastside County Water District, San Mateo County), but they deserve further attention. It is no doubt true that water needs in the Bay Area will increase in the future, but the actual rate and extent of increase depends on population growth. Most predictions of growth seem to be essentially a straight line extrapolation from the growth rate of the last decade. The logic of using this method is questionable. Population growth cannot be considered an independent variable. It is dependent upon economic conditions, basic human and cultural needs such as food, water, shelter and transportation and attitudes concerning consumption and environmental quality. Biological theory assumes that the concentration of the factor least available will limit a population. It is not unreasonable to assume that the same holds true for human populations. Water could well be the limiting factor for population growth in the Bay Area; water supply and population should be seen as two interdependent variables. The two interact in complicated ways. For instance, a large increment in water supply may stimulate population growth to a level not possible without that increase. This large population, in turn, will increase the demand for water. There is no simple cause-effect relationship between water supply and population growth.

While it may be foolish to predict a manifold increase in population size during the next several decades it is equally foolish to expect that no growth will occur. The present rate of growth has a momentum that cannot be stopped immediately. We are consequently still confronted with the necessity of supplying greater quantities of water and discarding ever-increasing volumes of wastes from a growing population.

This problem is not likely to diminish, at least for the next several decades, either in the San Francisco Bay Area or the State of California. It was the awareness of such water shortages which led the water-developers of the past to take the courses of action which we discussed in Chapter Two, and to develop the State Water Project and the Central Valley Project.

FOOTNOTES

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31. Telephone interview with Mr. B. G. Grant, Public Relations Department, Marin Municipal Water District, Corte Madera.

32. Telephone interview with Mr. Eugene Churchill, Public Relations Department, North Marin Water District, Novato.

33. Interview with Mr. Gordon Laverty, *op. cit.*

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36. Bechtel Corporation, *Preliminary Economic Analysis of Municipal Wastewater Renovations*, July 1968.

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Chapter Four

THE CALIFORNIA WATER PLAN: THE PROBLEM OF OPTIMAL RESOURCE ALLOCATION

How a society determines optimal resource allocation, when confronted with finite – limited – natural resources, is a major question, which will assume ever greater significance in the coming decades if population growth continues to soar. We have seen some answers to this question, in microcosm, for the State of California and its fresh water resources.

I. Mechanisms for Attaining Optimal Resource Allocation

Traditionally, decisionmakers have employed the benefit-cost analysis to determine which decision is the "best" or optimal solution. (See Chapter Three.) Depending on the type of quantification used to weigh various costs and supposed benefits, this search for optimality can lead to very biased decisions. All too often benefit-cost analysis is a quantitative sham to justify a decision which was reached *before* the analysis had even been carried out. The individuals calculating the b/c ratio were simply told that higher authorities wanted a given project approved; consequently, the quantitative estimate of benefits had to be greater than costs. It is unfortunate that a technique such as this is misused, for it is potentially a powerful aid to our decisionmaking process.

A. The Market System and Resource Allocation.

Allocation of resources within a free market is generally accomplished through a pricing system. Classic economic theory holds that the interaction of self-interest and competition between consumer and producer will result in the production of goods wanted by society at a profitable price for the manufacturer and seller. In other words, this interaction creates an effective market demand – a combination of willingness and ability to pay a profitable price. For example, individuals will commit resources to the manufacture of electric can openers so long as society wants these badly enough to pay for them – to make

resource investment in this area more profitable than alternative investments. Classically, goods are called forth by market demand, and the quantity produced as well as their price is determined by an interaction of such demand with the costs of supplying those goods. Unfortunately, many aspects of environmental quality are not amenable to government by the supply and demand principles of traditional markets.

In part this is so because components of environmental quality cannot be neatly packaged and sold; they are used in common and not subject to allocation by private markets. Thus, for example, the industry that pollutes the air does not pay for its use of the clean air resource; the social cost of polluting the air is imposed upon the public, and the industry has no incentive to curtail its polluting activity.

B. Bargaining Dynamics Applied to Air Pollution

Even though a product may not be amenable to pricing and to market sale, this does not mean that this resource cannot be optimally allocated through other means. We can illustrate this through a simple example involving air pollution.

Assume that a factory emits smoke, which is objectionable to surrounding residents. The cost imposed by the smoke falls on this population. Let us further assume that through land develuation, nuisance, increased pulmonary disease, and property damage, the pollution generates an aggregate cost to the community of $200,000. However, we shall also assume that the community gains, through the factory's job payroll, both direct and indirect benefits totaling $199,000. The net cost currently being born by the residents is, therefore, $1,000. A precipitator, on the other hand, which could completely eliminate all polluting emissions, costs only $1,500. (While such cost accounting is easy for us to do in this model, in reality this assessment of costs and benefits is exceedingly difficult. Nonetheless, starting with these few assumptions, let us continue our analysis to see where it directs our thinking.)

If the residents and the factory may freely bargain with each other, and if the residents possess an enforceable legal right to clean air, the residents will receive payment from the factory for the privilege of generating smoke. (Obviously, if the residents fear that they will lose their jobs, then they would not be able to "freely bargain.") It is cheaper, in effect, for the factory owner to "bribe" the residents to allow him to pollute than it is for him to eliminate the pollutants. The precise amount which the factory owner will pay the residents is indeterminate. Since, according to our model, the residents will be willing to permit pollution for payment of any amount greater than $1,000, and since the factory owner will be willing to pay any amc nt less than $1,500; the exact compensatory cash flow will depend on the relative bargaining strength of the two parties (1). Of course, if the polluter initially has the legal right to pollute, as has been the case by tacit decision in this country, then he will have no need to bargain. The result in either case will be polluted air.

If we reverse the cost patterns above, such that the residents suffer damages totaling $1,500 from unrestricted pollution, while the cost of installing pollution control equipment is only $1,000, we arrive at a pleasantly different result. Since clean air is now worth more to the community than it costs the factory to control it smoke, a legal right to clean air will force the factory to control the pollution. On the other

hand, a right to pollute will result in the residents "bribing" the factory to install precipitators. In either case the compensatory cash flow will result in clean air.

One of the problems in the United States, though, is deciding with whom the legal right resides: with the pollutor or those who must live with the consequences of pollution; and who, then, should subsequently bear the cost of pollution control. This legal question has important ramifications for the economic decisionmaking process. However, from a theoretical economic perspective what is significant here is the conclusion that when two parties may freely bargain with each other, without incurring cost through the bargaining process (costless bargaining) and when the cost of controlling pollution is less than the total cost to society produced by the pollution, then pollution will be stopped (2). In other words, the potential benefits generated by correction outweigh the cost of that solution, and we have a b/c ratio greater than one. Thus, where two parties may bargain with each other compensatory arrangements negotiated will produce an optimal resource allocation – in this case the level of environmental quality which represents the greatest net benefit to society. Another quite delightful implication of this theoretical analysis is that even nonmarketable goods can be optimally allocated automatically if bargaining occurs among adversaires. The unfortunate reality, however, is that environmental problems are still with us. The collection of resources under human control are not being allocated in a manner that meets man's needs as adequately as possible.

C. The Failure of Bargaining Institutions

1. Cost

Some of the reasons for our failure to achieve optimal resource allocation are perhaps obvious. One is that, in fact, bargaining does *not* occur among different sectors of the economy. Bargaining is not cost*less* but rather cost*ly*. The high cost of bargaining is probably the most significant factor contributing to our failure to properly allocate resources. For example, the community might fear that the factory will move to another city, offering the region the direct and indirect benefits such an industrial operation brings. This is merely another factor which might reduce the potential benefits, making bargaining too costly. Before residents may bargain with a factory owner, they must organize themselves into an effective bargaining unit. Since this requires expenditures of both time and money by community residents, it is difficult to achieve the requisite cooperation. To return to our limited air pollution example, benefits gained in the form of cleaner air by a small part of the resident group will inevitably be shared by every resident, whether or not they contributed to the effort involved in obtaining those benefits. Here the attitude "let somebody else do the dirty work," comes into play. There will be a tendency for each individual to try to maximize his gain by waiting for someone else to make the required expenditure. In this way he can enjoy the fruits of this labor without cost to himself.

Even if this hurdle is overcome the actual process of negotiation between factory owner and community residents may well require cost studies, drafting legal documents, and hiring negotiators, all of

which can be very expensive. Finally, the enforcement of contractual rights may demand expensive litigation. If the aggregate costs, which these obstacles pose to effective bargaining, exceed the amount of benefit which bargaining will achieve, then there will be no compensatory cash flow between parties. The result will be either completely clean air or unrestricted pollution, depending on the initial placement of legal rights.

This example brings up another highly pertinent point. The theorist might argue that since we are in fact faced with air pollution and other examples of what some might term environmental misuse, the social community, as one side of the bargaining pair, tacitly sees it in its best interest not to bargain. In other words the costs are too high when compared with expected benefits. As we have discussed, this may well be the case; it does not necessarily mean, however, that the people are indifferent to polluted air. The assumptions underlying such a benefit-cost approach imply that the community does in fact have financial resources which it could spend on bargaining, as one of several alternatives. Additionally, these assumptions imply that the residents made an assessment of potential benefits *vs.* cost to order their priorities and that bargaining came out low.

Inner-city residents, who are most often the victims of concentrated air pollution, do not even have capital reserves to spend in the first place. Consequently, they do not have the option to consider whether they should spend it trying to bargain with corporate managers. Within this context the establishment of priorities for the use of community funds in meaningless. *When the money is not even available*, this benefit-cost model collapses.

2. Difficulties in Resource Allocation

We encounter the same difficulty applying our model in other areas of environmental resource allocation as well – areas not necessarily tied directly to urban, inner-city problems or to pollution generation. Bargaining often fails to take place in the allocation of lumbering rights, wilderness reserves, and water rights, among others. Those who attempt to profit from exploitation of the environment are backed by corporate power, which means corporate money, corporate legal staffs, corporate public relations men, and corporate lobbyists. Those who are attempting to preserve the environment do not have such impressive financial and legal resources, for they are not *selling* anything. Rather, they are trying to save, and as with a bank savings account, the benefits are not immediately apparent but realized over a long period. The capital reserve lacked by those seeking the long-term gain for society excludes them, *de facto*, from the bargaining process. This exclusion shifts the balance of power toward those who are making the short-term economic gain.

3. The Corporation and Society

Since the corporation exists as an integral part of the society in which it functions, imbalance in bargaining dynamics may well be detrimental, in the long-run, to the corporation. Given this interrelationship between the corporation and society, the long-term cost of a corporate decision to society, and through society to the corporation itself, may more than offset the possible short-term gain that is so

attractive to corporate management, which legitimately seeks to maximize its market share price in the company stockholders' short-term interests.

Our air pollution model showed how costless bargaining between those groups who are affected by all benefits and costs of short-term decisionmaking generates an allocation of resources which more nearly approaches an optimal condition for society over a longer-term period. Those who make corporate decisions within such a context must make them with a view to the future for they are forced to consider costs which are presently passed on to society without being internalized by the corporate structure.

Without internalization of costs, private industry has little incentive to act in response to appeals to its sens of "moral" obligation or social responsibility. The effect of such pleas is likely to be far greater on a firm's public relations activities than on actual production policy changes. Even where social concern has tempered management's profit motive it cannot be expected to attend the public welfare without prior assurance that its competitors will take similar action.

If the market system or bargaining institutions cannot provide such assurance, then perhaps democratically-controlled government institutions could make decisions to allocate resources. This might be termed allocation by regulation, where the government happens to establish the decisionmaking criteria. As we are now finding out, unfortunately, drawbacks plague this approach, too.

D. Government Regulation

Regulation requires governmental bureaucracies or legislatures to undertake the vast benefit-cost calculations necessary to determine optimal environmental standards. This task is immense. In addition, we encounter the problem which we mentioned earlier, namely, the weighting of benefit or cost values to support pre-arranged decisions. The political pressures on existing regulatory bodies are considerable and, in fact, they often wind up being staffed by members or former-members of the very organizations they were meant to regulate! The net effect is that standards are set by processes which have little to do with the search for optimal allocation.

Furthermore, once standards are determined, the procedures used to enforce them are inevitably cumbersome. For example, the Assistant to the Secretary and Legislative Counsel of the Department of the Interior has described the process by which federal authority to control air pollution may be asserted:

> If there has been a discharge contributing to air pollution which endangers the health or welfare of persons in a State other than the one in which the discharge originates, the Governor of any State or a State air pollution control agency may ask the Secretary for action. The Secretary must give notice to the appropriate air pollution control agency and promptly call a conference. . . . If at the conclusion of the conference the Secretary is not satisfied that progress toward abatement is being made, he shall make appropriate recommendations to the State or municipal air pollution control agency and allow at least six months for his recommendations to be followed. Again, if no action is taken, the Secretary shall give notice and call a public hearing. At the conclusion of the hearing, the Board shall make recommendations to the Secretary who, in turn, forwards the Board's findings and recommendations to the party responsible for the contaminative discharges as well as to the air pollution control agency having jurisdiction of the area. It is only after compliance with this procedure that the Secretary may request court action by the Attorney General, and only in the case of interstate pollution (3).

Elaborate procedures, such as these, have been used with only minimal success to curb the pollution of Lake Erie.

E. Taxation Incentive Programs

A final approach to optimal resource allocation could be through government-provided taxation programs. Corporations would be taxed an amount proportional to the environmental damage they cause, either for example through pollution or through reduction of non-renewable resources. In this way they would be forced to internalize costs which are now externalities absorbed by society and never really fully analyzed in the benefit-cost decisionmaking process. Taxation programs suffer from the problem which also faces direct, governmental regulation. The agency involved must wade through a lengthy process to determine what amount of tax to apply to a given activity. Nonetheless, tax subsidies would work similar to bargaining, in that they would create compensatory cash flows to the affected segments of society (4).

Bargaining institutions and taxation which provide incentives to corporations for considering the costs their activities impose upon society and environmental quality may lack the political glamour of direct regulation, under which sharp questions are asked and gruff orders given. They can be exceptionally effective, however, for they use one of the most powerful instruments available to our economy: the profit motive. Incentive techniques enable the private sector to apply their ingenuity and productivity toward maximization of short-term gain, but within the context of long-term benefit.

F. Decisionmaking Objectives

Environmental decisionmaking's basic goal is to attain that level of environmental quality which represents an optimal allocation of society's resources. If we are dealing with resources which are subject to the theoretical market system, and the market works properly, governmental regulatory interference will be unnecessary. For numerous reasons, though, the classical concept of the market rarely works as it should. Furthermore, some goods are not amenable to market exchange and cannot be correctly allocated through its mechanisms. Although they could be allocated through costless bargaining among affected sectors of the economy, the existence of bargaining costs greater than projected benefits, or the absence of capital reserves to invest in the bargaining process, may prevent the compensatory cash flows necessary for optimal resource allocation. *The inability of either traditional markets or bargaining institutions to make these allocations results in what is often referred to as the "environmental problem."* (In actuality, though, this term is a misnomer. What we really mean is that there is a problem or potential problem related to continued human, social survival within the environment. This is not merely a semantic point, for it is through our consciousness and value structure that we perceive and create the existence of problems, environmental or otherwise. Thus, when we use a term like environmental problem we must think of it more as a people- or human-environmental problem. Solution, unfortunately, does not merely depend on spending a little more money here and a little more there. It requires a more fundamental re-evaluation of man's place in the ecosystem. As Galileo and Copernicus removed earth from the center of the universe, we

must now remove man from the center of the ecosystem.)

Governmental regulatory control of environmental quality, which we see today, is an attempted solution. While the alternatives range from moral suasion to direct regulation, the approach most neglected — improvement of bargaining institutions to insure compensatory cash flows, with a minimum of bureaucratic involvement — may well represent the most efficient means for attaining wise management of environmental resources.

II. The California Water Plan

The California Water Plan is one state's attempt to devise a comprehensive formula for optimal allocation of available water resources (5, 6). Some of the original water project proposals, carried out by the state and federal government, were first put forth in the 1930's. The California Water Plan was officially presented for the first time in the State Department of Water Resources' 1957 publication, *Bulletin No. 3*. This was one of the first documents produced by the new department, which had been created only the year before to replace the State Water Resources Department. The role which the State Department of Water Resources (CDWR or DWR) plays in water resource allocation is an interesting one, particularly within the context of our discussions earlier in this chapter. DWR is first the planning agency for water resources. DWR as a public agency involved in the stewardship of public resources plans water distribution programs. Their goal is optimal allocation of this limited resource. They also have a role similar to that of the private entrepreneur in that they sell these same water resources to private corporations, both industrial and agricultural, to farmers, and to municipal agencies. Their function is neither completely that of public steward nor private corporation. It contains elements of both, and at times this creates awkward situations. For example, up to what point should contractual commitments to a private interest be honored despite possible detriment to a large section of the State? This is a problem with which the Department has wrestled; currently it has opted to honor contractual commitments.

The California Water Plan, designed by the DWR, is not a specific *project*, neither federal, state, nor municipal, but rather a "long-range planning framework for the development of California's water resources (7)." In Chapter Two, we detailed the sequence of projects leading to the ultimate formulation of the Plan.

The major components of the California Water Plan today include the controversial California State Water *Project*, now nearing completion, and the federally-managed Central Valley Project, which has also been partially constructed. There are additional local and federal projects which contribute toward achieving the objectives of the California Water Plan.

A. The State Water Project and Central Valley Project

The State Water Project, planned, administered, and constructed by the State Department of Water Resources, has been built solely with state funds. The Central Valley Project began in the 1930's as a state program (See Chapter Two.) but passed into federal hands as a result of the Depression. It is currently managed by the Department of Interior's Bureau of Reclamation. Of these two major programs: the State

Water Project (SWP) and the federal Central Valley Project (CVP), the latter will have far greater impact on the resource distribution of the State, as is shown in Table 4-1. (See Fig. 2-1 for a map showing the 11 hydrologic areas in the State and Fig. 2-2 for an overview of federal, state, and municipal projects.) The

Table 4-1 (8)

Summary of Current and Future Water Demands on EXISTING Facilities of the Central Valley Project and State Water Project (In Million Acre-Feet)

Hydrologic Study Area	Central Valley Project			State Water Project		
	1967	1990	2020	1967	1990	2020
San Francisco Bay	0.060	0.220	0.460	0.060	0.230	0.260
Central Coastal	0.000	0.080	0.110	0.000	0.080	0.080
South Coastal	- -	- -	- -	0.000	1.190	2.200
Sacramento Basin	2.210	2.750	3.080	0.000	0.040	0.040
Delta-Central Sierra	0.980	1.270	1.330	- -	- -	- -
San Joaquin	1.580	1.670	1.720	0.000	0.010	0.010
Tulare Basin	1.460	2.690	2.690	0.000	1.350	1.350
South Lahontan	- -	- -	- -	0.000	0.210	0.210
Colorado Desert	- -	- -	- -	0.000	0.080	0.080
Recreation Deliveries & Conveyance Losses	- -	0.050	0.050	- -	0.290	0.290
TOTAL DEMANDS ON THE CVP and SWP	6.290	8.730	9.440	0.060	3.480	4.520

Central Valley Project is presently delivering 10 times more water than the State Water Project and by 2020 will still be conveying twice the number of Acre-Feet per Year (AFY) that the SWP will be transporting.

The California Water Plan comprehensively plans to make water resources available for multiple uses – domestic, industrial development, electrical power generation (fossil fuel steam, nuclear steam, hydroelectric, and geothermal), agricultural expansion, recreational use, and fish and wildlife maintenance. It also provides for flood damage prevention, maintenance of water quality standards, and water quality control.

Within this general rubric, the State Water Project is a specific engineering development designed to transport water from the water-rich northern North Coastal and Sacramento Basins to the southern portions of the State. The water would be used primarily for irrigation in the Central Valley region, to bring desert acreage into agricultural production, and to supply the projected population demands of the Los Angeles basin.

The State Water Project initially began as the Feather River Project in 1951 (See Chapter Two). During that decade it expanded and, in 1959, the passage of the Burns-Porter Act authorized the Project at its present magnitude. The SWP is now 95 percent completed or already contracted, and will ultimately

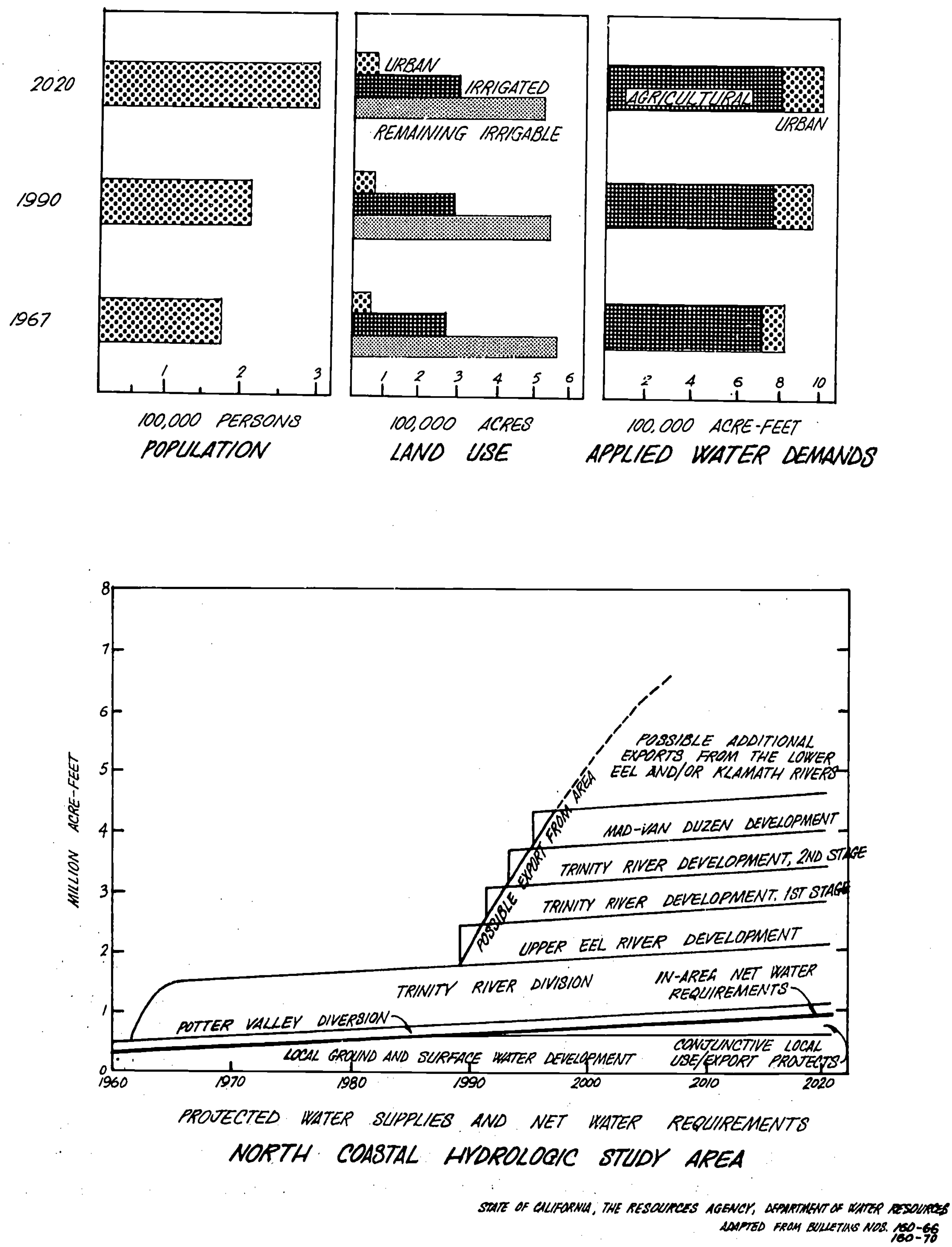

2020
1990
1967
1 2 3
100,000 PERSONS
POPULATION
URBAN
IRRIGATED
REMAINING IRRIGABLE
1 2 3 4 5 6
100,000 ACRES
LAND USE
AGRICULTURAL
URBAN
2 4 6 8 10
100,000 ACRE-FEET
APPLIED WATER DEMANDS
MILLION ACRE-FEET
0 1 2 3 4 5 6 7 8
1960 1970 1980 1990 2000 2010 2020
POSSIBLE ADDITIONAL EXPORTS FROM THE LOWER EEL AND/OR KLAMATH RIVERS
POSSIBLE EXPORT FROM AREA
MAD-VAN DUZEN DEVELOPMENT
TRINITY RIVER DEVELOPMENT, 2ND STAGE
TRINITY RIVER DEVELOPMENT, 1ST STAGE
UPPER EEL RIVER DEVELOPMENT
TRINITY RIVER DIVISION
IN-AREA NET WATER REQUIREMENTS
POTTER VALLEY DIVERSION
LOCAL GROUND AND SURFACE WATER DEVELOPMENT
CONJUNCTIVE LOCAL USE/EXPORT PROJECTS
PROJECTED WATER SUPPLIES AND NET WATER REQUIREMENTS
NORTH COASTAL HYDROLOGIC STUDY AREA
STATE OF CALIFORNIA, THE RESOURCES AGENCY, DEPARTMENT OF WATER RESOURCES
ADAPTED FROM BULLETINS NOS. 160-66 160-70

Figure 4-1

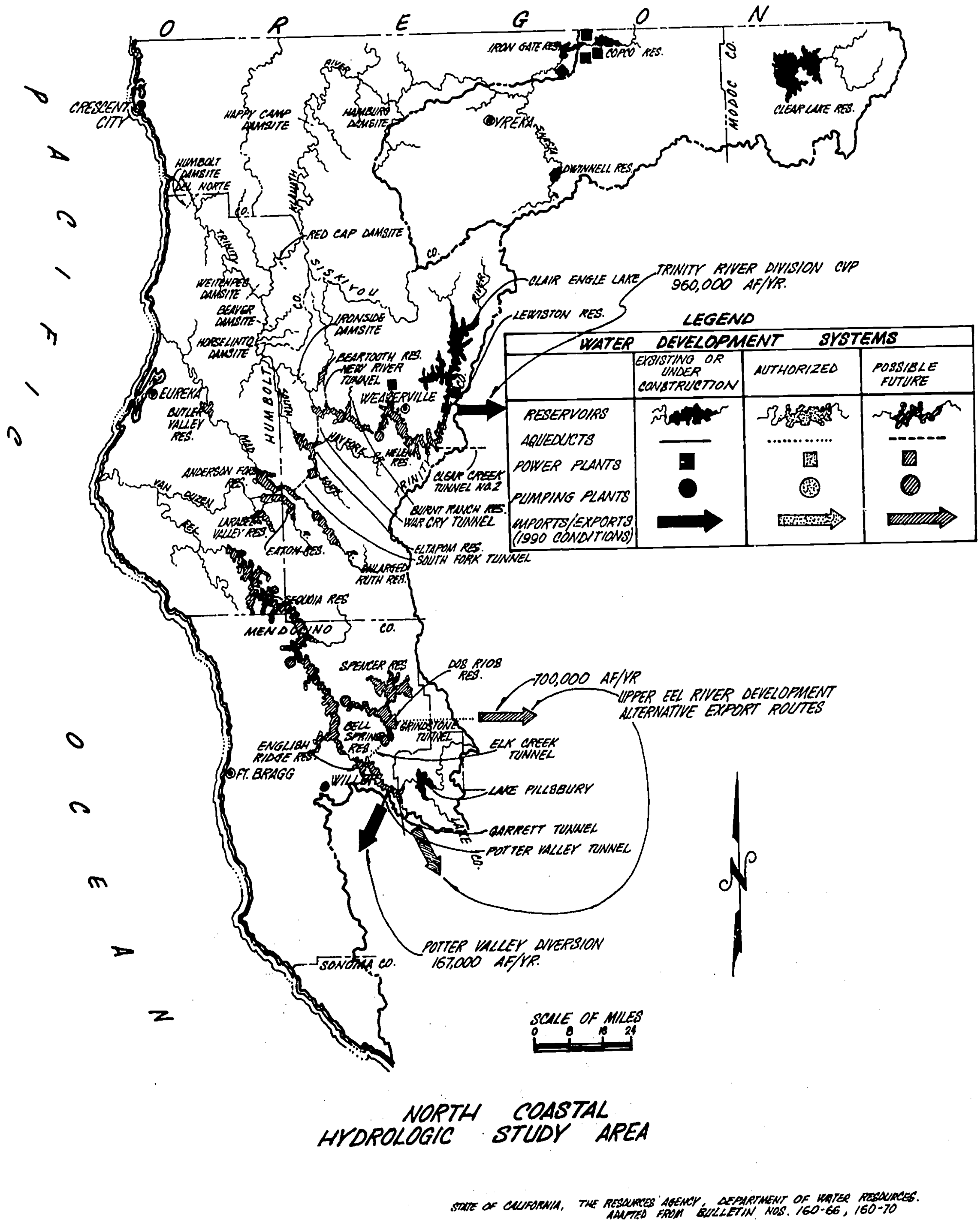
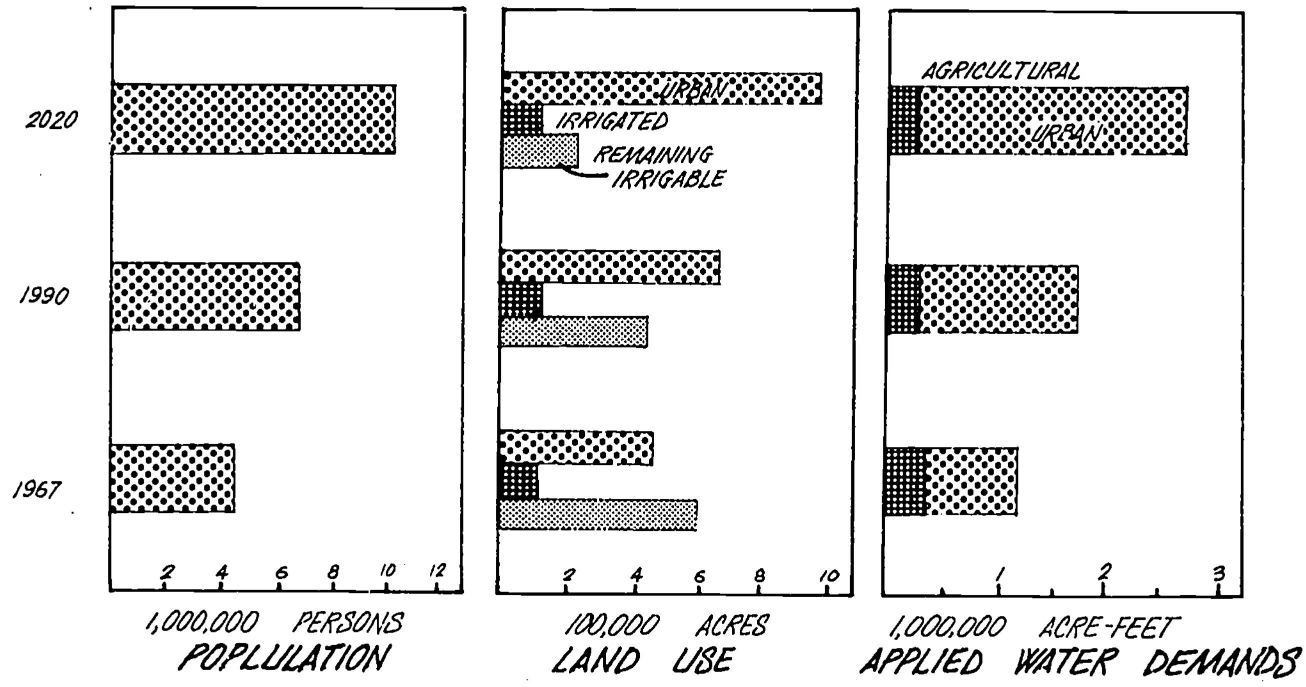
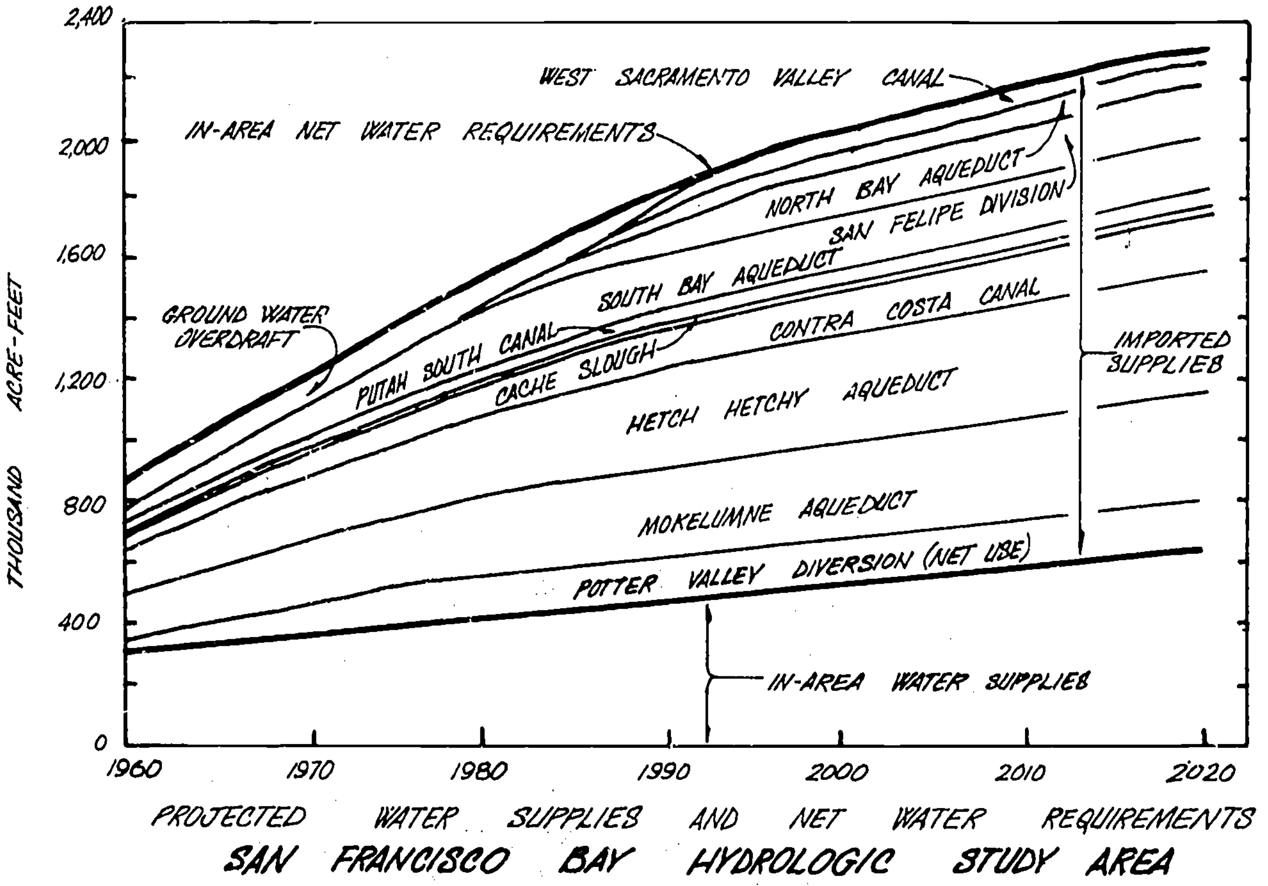

OREGON
PACIFIC OCEAN
CRESCENT CITY
IRON GATE RES.
COPCO RES.
CLEAR LAKE RES.
MODOC CO.
HAPPY CAMP DAMSITE
HAMBURG DAMSITE
YREKA
DWINNELL RES.
HUMBOLT DAMSITE
DEL NORTE
RED CAP DAMSITE
SISKIYOU
WEITCHPEC DAMSITE
BEAVER DAMSITE
HORSE LINTO DAMSITE
IRONSIDE DAMSITE
BEARTOOTH RES.
NEW RIVER TUNNEL
WEAVERVILLE
CLAIR ENGLE LAKE
LEWISTON RES.
TRINITY RIVER DIVISION CVP 960,000 AF/YR.
EUREKA
BUTLER VALLEY RES.
HUMBOLT
ANDERSON FORD RES.
HELENA RES.
CLEAR CREEK TUNNEL NO.2
BURNT RANCH RES.
WAR CRY TUNNEL
ELTAPOM RES.
SOUTH FORK TUNNEL
LARABEE VALLEY RES.
EATON RES.
ENLARGED RUTH RES.
SEQUOIA RES.
MENDOCINO CO.
SPENCER RES.
DOS RIOS RES.
700,000 AF/YR
UPPER EEL RIVER DEVELOPMENT ALTERNATIVE EXPORT ROUTES
BELL SPRINGS RES.
GRINDSTONE TUNNEL
ENGLISH RIDGE RES.
FT. BRAGG
ELK CREEK TUNNEL
LAKE PILLSBURY
GARRETT TUNNEL
POTTER VALLEY TUNNEL
POTTER VALLEY DIVERSION 167,000 AF/YR.
SONOMA CO.
LEGEND
WATER DEVELOPMENT SYSTEMS
EXISTING OR UNDER CONSTRUCTION
AUTHORIZED
POSSIBLE FUTURE
RESERVOIRS
AQUEDUCTS
POWER PLANTS
PUMPING PLANTS
IMPORTS/EXPORTS (1990 CONDITIONS)
SCALE OF MILES
0 8 16 24
NORTH COASTAL HYDROLOGIC STUDY AREA
STATE OF CALIFORNIA, THE RESOURCES AGENCY, DEPARTMENT OF WATER RESOURCES.
ADAPTED FROM BULLETIN NOS. 160-66, 160-70

Figure 4-2





STATE OF CALIFORNIA, THE RESOURCES AGENCY, DEPARTMENT OF WATER RESOURCES
ADAPTED FROM BULLETIN NOS. 160-66, 160-70

Figure 4-3

SAN FRANCISCO BAY
HYDROLOGIC STUDY AREA

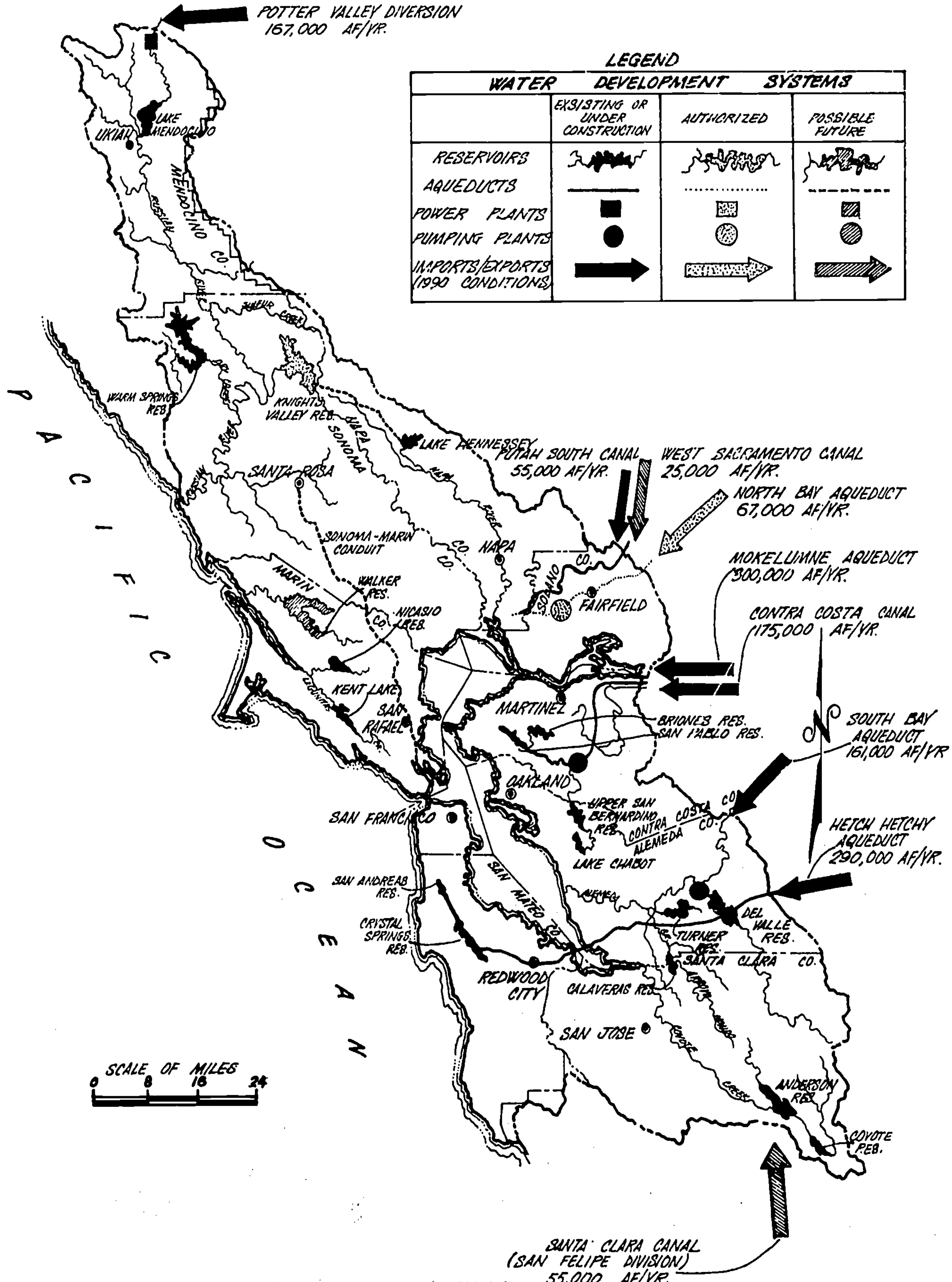


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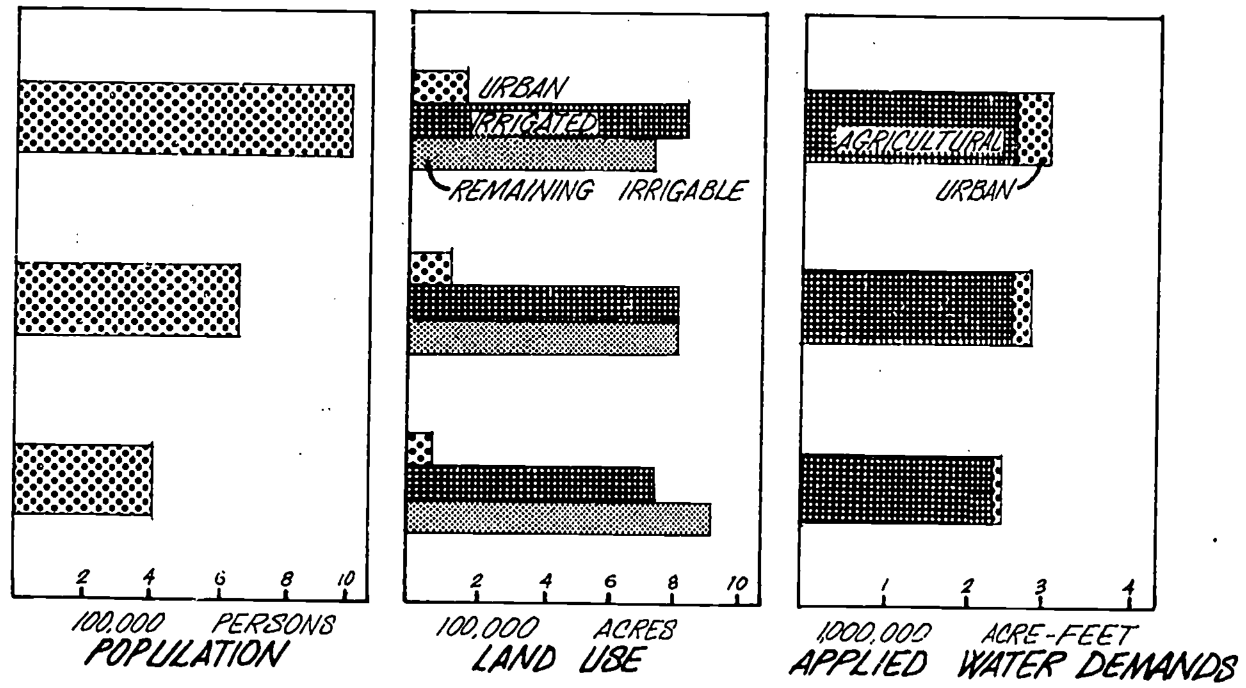
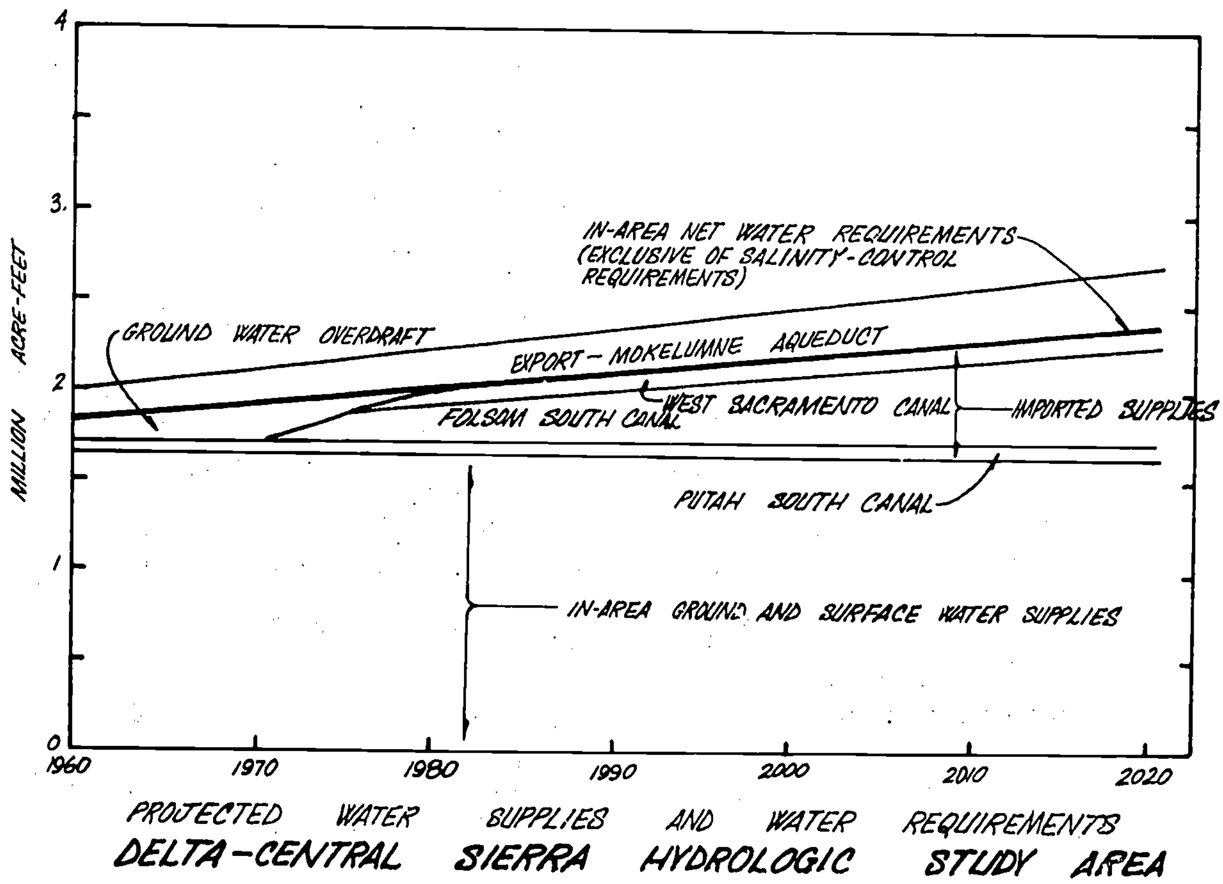
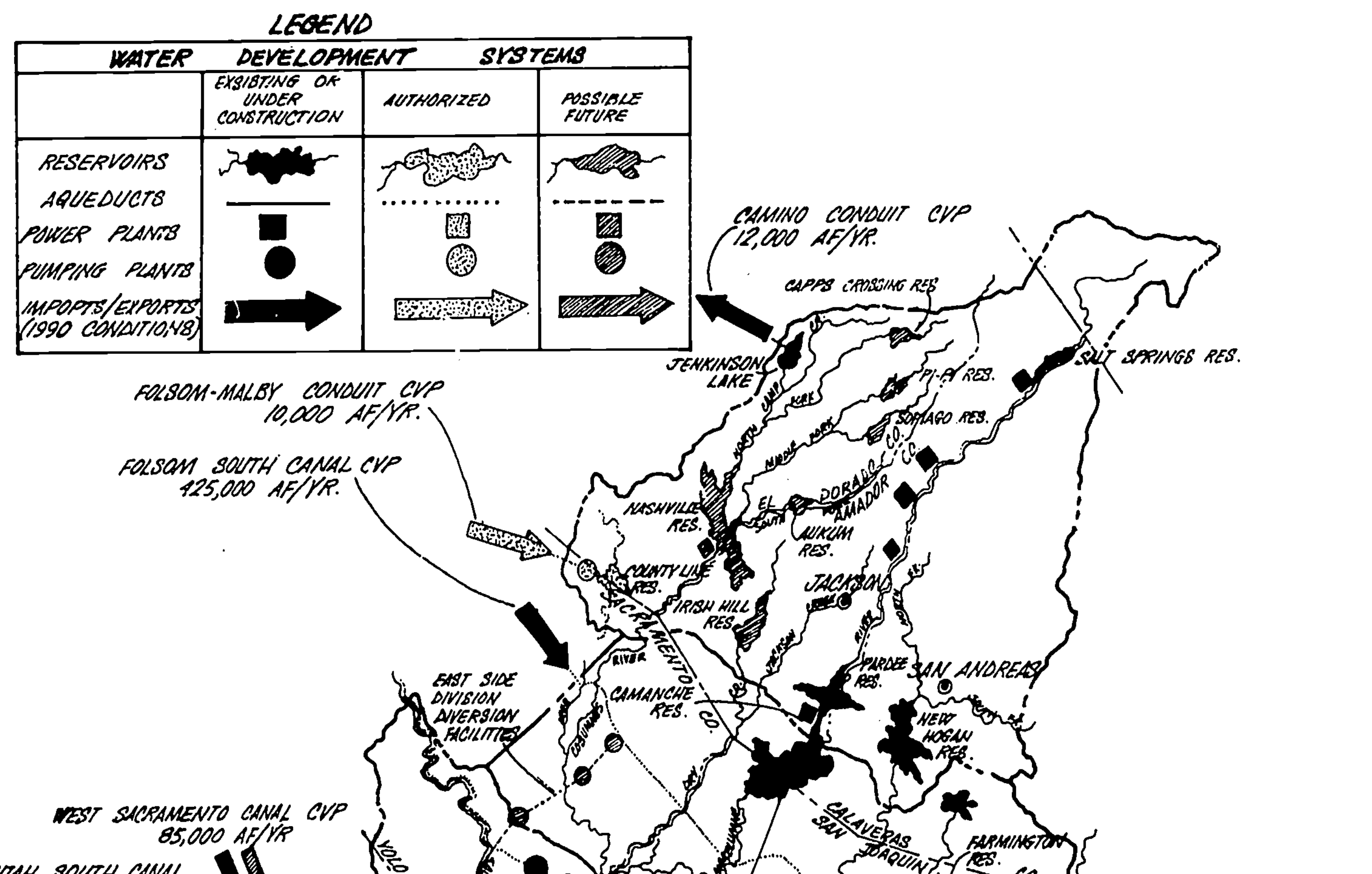
Figure 4-4





STATE OF CALIFORNIA, THE RESOURCES AGENCY, DEPARTMENT OF WATER RESOURCES
ADAPTED FROM BULLETINS NOS. 160-66
160-70

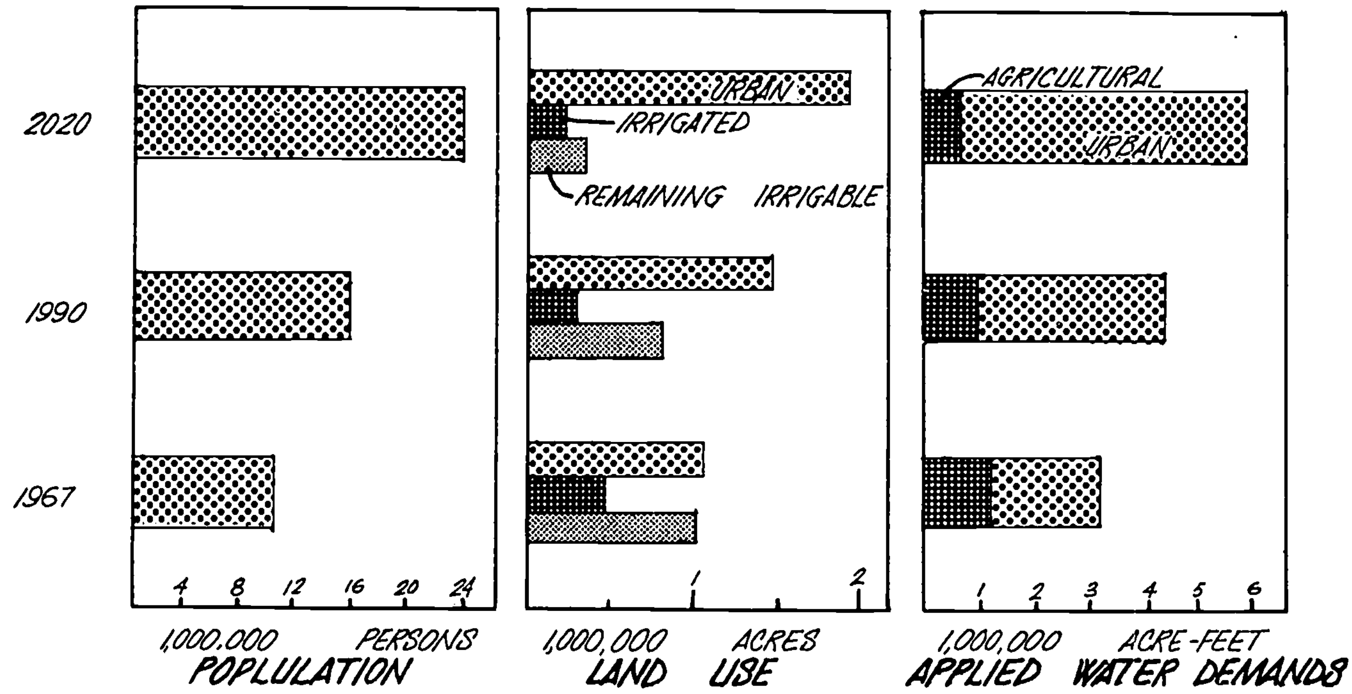
Figure 4-5

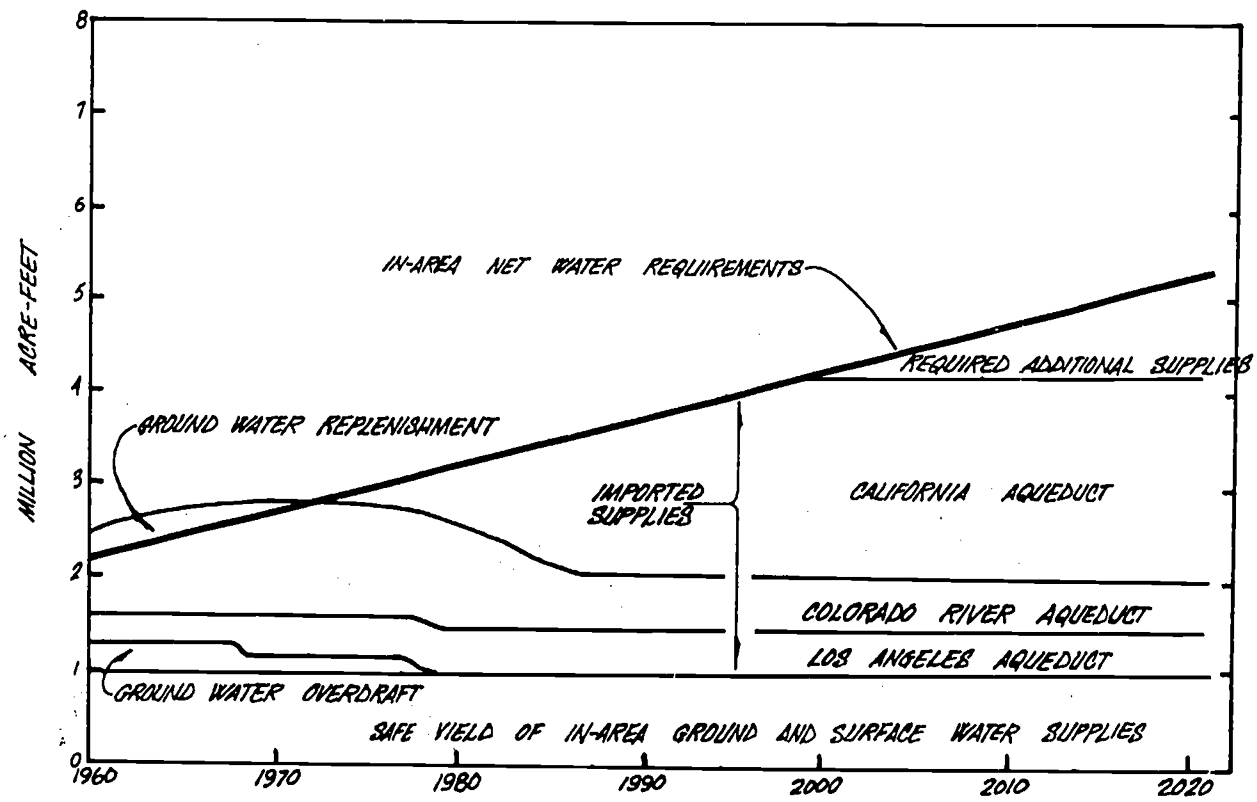


DELTA - CENTRAL SIERRA
HYDROLOGIC STUDY AREA

STATE OF CALIFORNIA, THE RESOURCES AGENCY, DEPARTMENT OF WATER RESOURCES
ADAPTED FROM BULLETIN NOS. 160-66, 160-70

Figure 4-6





PROJECTED WATER SUPPLIES AND NET WATER REQUIREMENTS
SOUTH COASTAL HYDROLOGIC STUDY AREA

STATE OF CALIFORNIA, THE RESOURCES AGENCY, DEPARTMENT OF WATER RESOURCES
ADAPTED FROM BULLETIN NOS. 160-66, 160-70

Figure 4-7

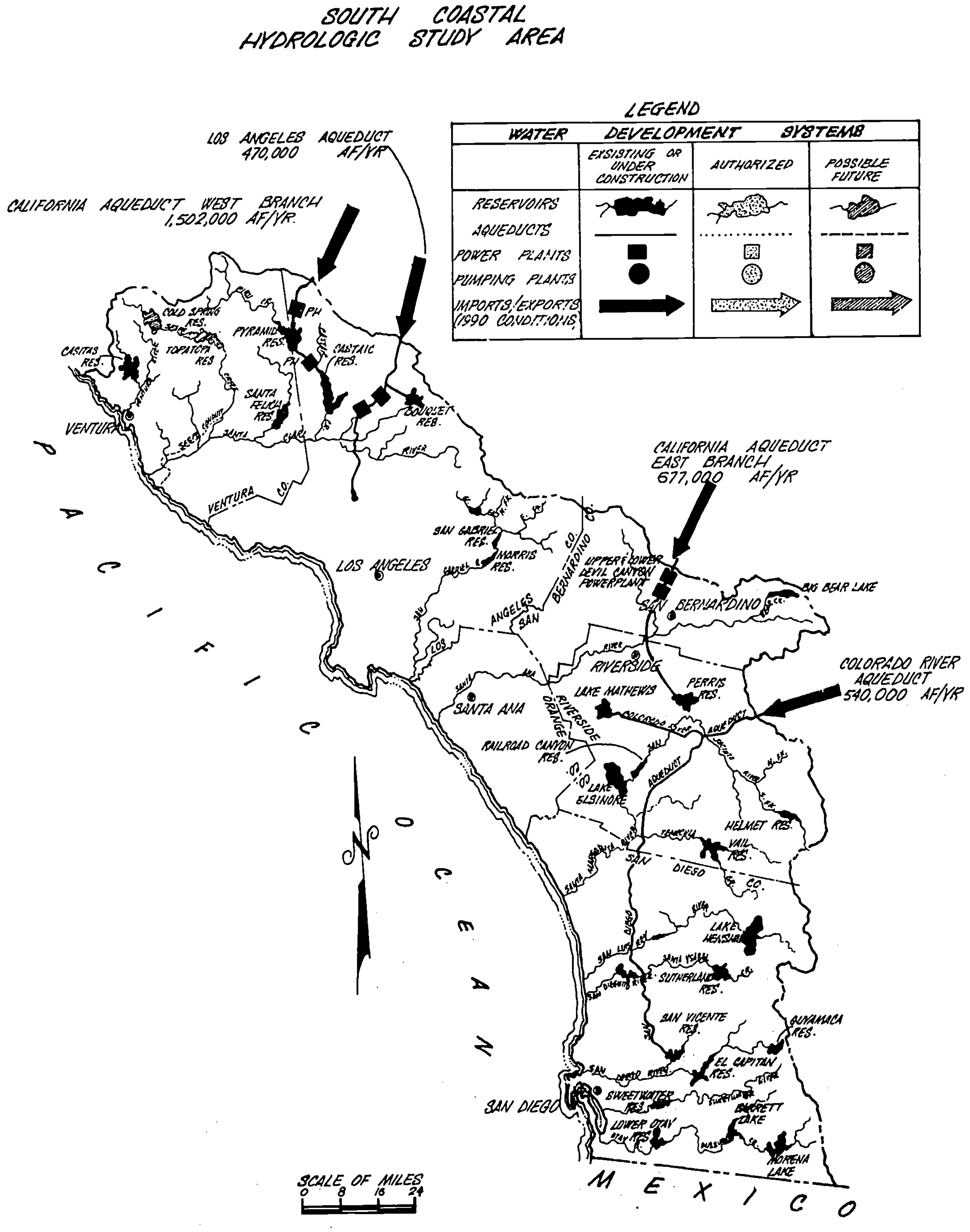
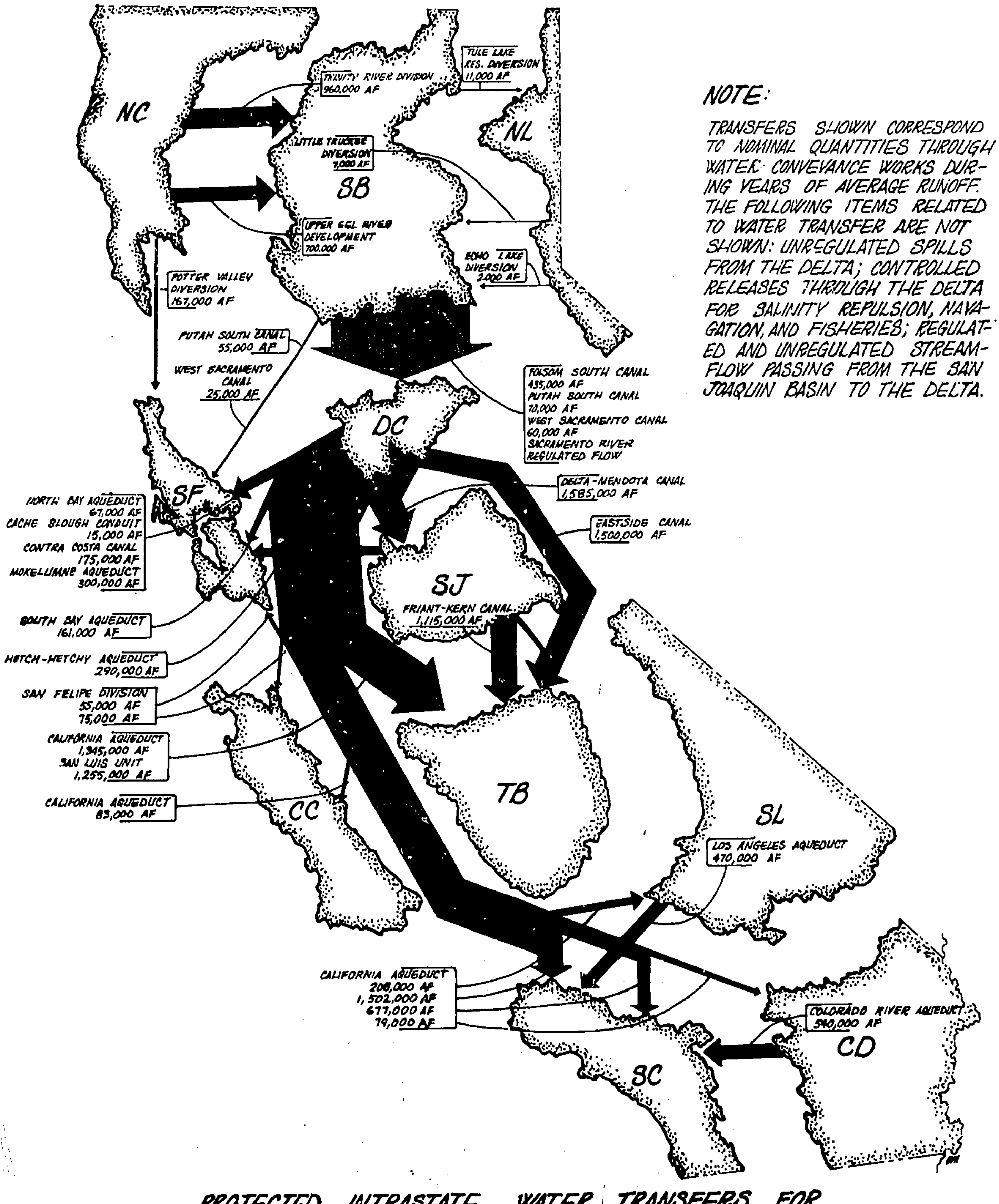

SOUTH COASTAL
HYDROLOGIC STUDY AREA
LEGEND
WATER DEVELOPMENT SYSTEMS
EXISTING OR UNDER CONSTRUCTION
AUTHORIZED
POSSIBLE FUTURE
RESERVOIRS
AQUEDUCTS
POWER PLANTS
PUMPING PLANTS
IMPORTS/EXPORTS (1990 CONDITIONS)
LOS ANGELES AQUEDUCT 470,000 AF/YR
CALIFORNIA AQUEDUCT WEST BRANCH 1,502,000 AF/YR.
CALIFORNIA AQUEDUCT EAST BRANCH 677,000 AF/YR
COLORADO RIVER AQUEDUCT 540,000 AF/YR
PYRAMID RES.
CASTAIC RES.
CASITAS RES.
SANTA FELICIA RES.
VENTURA
VENTURA CO.
LOS ANGELES
SAN GABRIEL RES.
MORRIS RES.
UPPER & LOWER DEVIL CANYON POWERPLANT
SAN BERNARDINO
BIG BEAR LAKE
RIVERSIDE
LAKE MATHEWS
PERRIS RES.
SANTA ANA
RAILROAD CANYON RES.
LAKE ELSINORE
HELMET RES.
VAIL RES.
SAN DIEGO CO.
LAKE HENSHAW
SUTHERLAND RES.
SAN VICENTE RES.
CUYAMACA RES.
EL CAPITAN RES.
SWEETWATER RES.
SAN DIEGO
LOWER OTAY RES.
BARRETT LAKE
MORENA LAKE
PACIFIC OCEAN
MEXICO
SCALE OF MILES
0 8 16 24
STATE OF CALIFORNIA, THE RESOURCES AGENCY, DEPARTMENT OF WATER RESOURCES
ADAPTED FROM BULLETIN NOS. 160-66; 160-70

Figure 4-8



PROJECTED INTRASTATE WATER TRANSFERS FOR
1990 LEVEL OF DEVELOPMENT

ADAPTED FROM
BULLETIN No. 160-66

Figure 4-9

encompass 21 major dams and reservoirs; the 444-mile-long California Aqueduct (portions of which are used jointly with the federal Bureau of Reclamation); numerous other aqueductal facilities, including the South Bay Aqueduct and North Bay Aqueduct; 22 pumping plants; and 7 power plants (9).

Figures 4-1, 4-3, 4-5, and 4-7 present detailed information about population projections, land use, applied water demands, and about projected water supplies *vs.* net requirements for the North Coastal, San Francisco Bay, South Coastal, and Delta-Central Sierra hydrologic study areas. Figure 2-1 places these four regions in statewide context. Figures 4-2, 4-4, 4-6, and 4-8 show water development systems in detail, as well as their current construction status, in these same four regions. Figure 4-9 is an exploded map of California showing intrastate water transfers in graphic form. From this figure we can readily see that the Delta-Central Sierra Basin, which contains the Sacramento-San Joaquin River Delta system feeding into the San Francisco Bay, is really the hub of the California Water Plan. To facilitate interpretation of these maps, Table 4-2 outlines the major components of the Central Valley Project (CVP) and the State Water Project (SWP). (N.B.: The San Luis *Canal* of the CVP should not be confused with the San Luis *Drain* of the CVP. The former is part of a fresh-water conveyance system, while the latter is an agricultural drain, carrying waste run-off from Central Valley fields. The Drain is discussed further in Chapter Five.)

Table 4-2 (10)

Major Features of the CVP and SWP Systems

Central Valley Project	**State Water Project**
Major Reservoirs	Major Reservoirs
Shasta	Oroville
Clair Engle (Trinity)	San Luis*
Whiskeytown	Pyramid
Auburn	Castaic
Folsom	Silverwood (Cedar Springs)
San Luis*	Perris
New Melones	
Millerton (Friant)	
Major Canals	Major Canals
Corning	North Bay Aqueduct
Tehama-Colusa	Peripheral Canal*
Folsom South	South Bay Aqueduct
Peripheral Canal*	California Aqueduct
Contra Costa	San Luis*
Delta Mendota	Coastal Branch*
San Felipe Division	West Branch*
Friant-Kern	
Friant-Madera	
California Aqueduct	
San Luis*	
Coastal Branch*	
West Branch*	

* Central Valley Project-State Water Project joint-use facilities.

B. The North Coast Region

Since the major portion of water which will be diverted under the California Water Plan will come from the northern portion of the state, specifically the North Coast Region, it is appropriate that we should begin our analysis of the effects of these aquatic diversion projects with this area. The need for water in other portions of the state is discussed in detail in Department of Water Resources *Bulletin 160-70*. We shall not evaluate the validity of the assumptions underlying these projects at this point, but rather shall spend the remainder of this chapter and Chapter Five attempting to assess their costs to the North Coast Area and to the San Francisco Bay region.

1. Area Description

Tucked in the northwest corner of California lies a remote, wild region that few people know. It is called the North Coast Area, and it engulfs nearly 20,000 square miles in Del Norte, Humboldt, Trinity, Mendocino and Tehama counties as it stretches from the Russian River drainage on the south to the Oregon border on the north and from the Pacific Ocean on the west to the drainage divides of the coastal mountains on the east (11) (See Figure 4-2 for a map of the area). Interlaced with the subranges of the Klamath Mountains – the Siskiyou, Trinity Alps, Marble, Salmon, Scott Bar, Scott, Yolla Bolly and Bullychoop Ranges – the region is crammed with alpine wonderlands, forests, and steep-sided canyons.

Somehow three of the largest rivers in California – the Eel River, the Klamath River and the Trinity River – manage to poke their way through the rugged canyons of these ranges and help 19.3 million acre feet of annual runoff escape to the Pacific Ocean (12) (See Figure 4-2). These mighty rivers carry 65% of the North Coast Area's long-term mean annual runoff and 26% of the annual California runoff (13).

2. Vegetation

Not all of the precipitation that falls on the North Coast Area escapes to the sea. Much of it stays to support a wide array of vegetation, whose distribution in the North Coast Area is largely a function of terrain, climate, altitude and soil type. Taking a transect across the Area from the coast to the Sacramento Valley, one sees that definite vegetation belts exist. Starting in the saturated coastal region, the expansive redwood belt sends it fingers as far as thirty-five miles from the ocean into the damp lowlands. Between the elevations of 2,000 feet and 4,500 feet, the Douglas Fir belt takes over. Above 4,500 feet and below the timberline is the Ponderosa Pine belt, dotted with woodland-grassland associations. Coming down from timberline on the eastern side one recognizes pine and Douglas Fir, but the redwood belt is missing. Instead, one finds the chaparral of eastern Mendocino, Trinity and Siskiyou counties.

3. Fish and Wildlife

Associated with these vegetation belts are fish and intertwining populations of wildlife. Columbian black-tailed deer, mountain lions, valley quail, band-tailed pigeons, gray squirrels, blue grouse, mallards, woodducks, mergansers, raccoons, gray foxes, river otters, minks, skunks, ring-tailed cats, bobcats and

coyotes are a few of the animals which call this region home (14). In the streams swim king salmon, silver salmon, sturgeon, shad, steelhead, resident rainbow trout, brown trout, brook trout, speckled dace, sculpins, dog salmon, suckers, lamprey eels and other fish.

Of the anadromous fish (those fish which ascend the rivers and streams from the sea for spawning), the king and silver salmon and the steelhead are the most important commercially and for recreation. Due to urbanization, agriculture, and water development, steelhead no longer spawn in the streams in the southern portion of the State. Spawning grounds remain primarily in the North Coast Area (15). These streams produce over 80% of the California steelhead, with the Klamath River having the largest steelhead run in the world (16).

About 350,000 king salmon annual spawn in the area's streams and rivers. Fisheries biologists believe that this figure represents about one-fourth of the adult fish produced by these streams, with the other three-fourths being captured by sports and commercial fishermen – which suggests that roughly 1.5 million harvestable king salmon are annually raised in the North Coast area (17).

Silver salmon are the least important of the three mentioned anadromous fish. They are abundant only north of Sonoma County, with most of the silver salmon being raised in the Klamath and Eel River Drainages. About 125,000 silver salmon annually spawn in the North Coast Area (18).

C. The State Water Project and the North Coast Area

1. Water Quality

As the sensitive trout, steelhead and salmon which dart through the North Coast testify, the water quality from the area's streams and rivers is "generally excellent (19). Except in the regions below Lake Pillsbury on the Eel River, Ruth and Sweasy reservoirs on the Mad River, and Lewiston Reservoir on the Trinity River, the river bottoms are loosely paved with gravel and sand of all sizes. The watersheds have had a chance to recover from the gold mining abuses of the mid-nineteenth century, and the rivers quickly flush the foreign silt and debris with thundering freshets. The rivers and streams usually roar clear and wild throughout the year. CVP's Trinity River Division, transporting 960,000 AFY and the Potter Valley Diversion, sending an additional 167,000 AFY out of this region. Contractual commitments of the State Department of Water Resources may necessitate that even greater quantities of water be shipped from the North Coast region to other parts of the State. Consequently, the California Department of Water Resources, the Bureau of Reclamation, and the Army Corps of Engineers are studying the feasibility of diverting 10 to 12 million of the 19.3 million acre feet of water annually which the Eel, Klamath and Trinity Rivers collect and send on to the Pacific Ocean (20). The proposals call for trapping the river water behind a series of dams on the Trinity, Eel, Van Duzen, Mad, New, and Klamath Rivers and transporting it through a maze of tunnels and pipes to the Sacramento River Basin. Most of the exported water would be used to satisfy the water needs for the lower three-fourths of California from the San Francisco Bay Region to San Diego. (See Table 4-3 for a list of the proposed dams, Table 4-4 for the runoffs at the sites of the proposed dams, Figure 4-2 for a map of their proposed locations.)

TABLE 4-3

Proposed Reservoirs

Reservoir	River	Cost (x $\$10^6$)	Gross Capacity (acre ft.)	Yield/year (acre ft.)
Dos Rios[a]	M. Fk. Eel	67.0	7,600,000	819,000*
English Ridge[a]	M. Fk. Eel	112.8	1,799,000	365,000*
Small Dos Rios[a]	M. Fk. Eel	67.0	536,000	819,000*
Spencer[a]	M. Fk. Eel	77.6	450,000	696,000*
Small Dos Rios with Spencer[a]	M. Fk. Eel	67.0	536,000	123,000*
Mina[a]	N. Fk. Eel	107.7	550,000	268,000*
Yellow Jacket[a]	Eel	326.0	8,680,000	579,000*
Willis Ridge[a]	Eel	23.4	75,000	–75,000*
Medium Dos Rios[a]	M. Fk. Eel	194.0	1,650,000	731,000*
Helena[b]	Trinity	84.0	2,860,000	600,000
Eltapom[b]	S. Fk. Trinity	55.0	730,000	400,000
Beartooth[b]	New River	35.0	36,000	120,000
Burnt Ranch[b]	Trinity	71.0	980,000	80,000
Larabee Valley[b]	S. Fk. Van Duzen	39.0	558,000	130,000
Eaton[b]	Van Duzen	29.0	635,000	200,000
Enlarged Ruth[b]	Mad	13.0	480,000	145,000
Anderson Ford[b]	Mad	30.0	160,000	125,000
Butler Valley[b,c]	Mad	13.0	75,000	220,000
Sequoia[b]	Eel	170.0	5,400,000	600,000
Bell Springs[b]	Eel	101.0	1,350,000	400,000
Humboldt[b]	Klamath	1,600.0	15,000,000	6,000,000
Schneiders Bar[d]	Trinity	. . .	343,000	. . .

*Storable inflow.

[a]Digested from the Department of Water Resources' *Bulletin No. 172: Eel River Development Alternatives* (January 1970). All costs adjusted to July, 1969. Cost = first cost — which includes initial recreation facilities.

[b]Digested from the Department of Water Resources' *Bulletin No. 136: North Coastal Area Investigation* (September 1964). Costs = estimated capital costs at 1964 rates.

[c]For local use only.

[d]From the Department of Fish and Game, *Preliminary Report.*

Table 4-4

Estimated Natural Runoff at Proposed Damsites
In the North Coastal Area

Damsite	Stream	Drainage Area Square Miles	50-yr. Mean Annual Natural Runoff (1911-1960) 1,000 A.F.	Max. Annual Runoff 1,000 A.F.	Min. Annual Runoff 1,000 A.F.	Av. Annual Runoff (1928-1934) 1,000 A.F.
Spencer	M.F. Eel River	426	735	1,645	128	445
Dos Rios	M.F. Eel River	745	1,022	2,433	156	547
English Ridge	Eel River	488	654	1,514	66	359
Bell Springs	Eel River	1,578	2,152	5,002	290	1,175
Sequoia	Eel River	2,241	3,166	7,339	473	1,794
Helena	Trinity River	1,299	1,909	4,418	346	1,095
Burnt Ranch	Trinity River	1,453	2,060	4,768	373	1,182
Ironside Mountain	Trinity River	1,705	2,489	5,759	451	1,430
Eltapom	S.F. Trinity River	767	936	2,060	155	550
Beartooth	New River	180	304	704	55	175
Ruth	Mad River	121	180	423	29	106
Anderson Ford	Mad River	211	331	777	52	196
Butler Valley	Mad River	352	740	1,294	208	513
Eaton	Van Duzen River	82	218	420	77	149
Larabee Valley	S.F. Van Duzen River	55	150	276	39	101
Humboldt	Klamath River	12,084	12,000	24,150	3,930	7,986

(Adapted from Department of Water Resources, *Bulletin No. 136.*)

2. Diversion Purposes

Initially the planning of these diversion structures was intended to be multi-purpose for water conservation, for local and export requirements, fisheries enhancement, recreation, flood control and hydroelectric generation (21). However, flood control is no longer a major goal, as it is too expensive to perform adequately (22). Hydroelectric power generation also is no longer a major goal. The proposed projects envision backpumping water from low reservoirs to high reservoirs and then over the mountains to the Sacramento Basin, and it would not be economical to generate hydroelectric power in the jagged canyons below the proposed reservoirs (23). The remaining goals are not weighted equally. When two goals conflict (for example: water export and flood control) a benefit-cost analysis is employed to determine the overriding goal (24). Water export now appears to be the primary goal for these proposed diversion projects.

3. Project Status

"Possible Future" are the most important adjectives used in describing the facets of the California Water Plan's objectives in the North Coast Area. Of the dozens of reservoirs, dams and conveyances which have been proposed for the area, only Trinity Reservoir, Lewiston Reservoir, and the Clear Creek Tunnel (which diverts 865,000 acre feet per year of Trinity River water to the Sacramento River Basin at Whiskeytown Reservoir) have been constructed (25). The structures on the Upper Middle Fork of the Eel River

were authorized for inclusion into the State Water Project on March 9, 1964 (26). But the planning for these structures was halted by Governor Reagan on November 14, 1969 (22). The Upper Middle Fork of the Eel developments and the five other developments on the North Coast Area rivers are proposed but are not currently authorized and will not begin without appropriate financing and authorization.

4. Project Phases (See Table 4-5)

The proposed North Coast Area developments can be separated into six sequential project phases. Phase One is the Upper Eel Development on the Upper Middle Fork of the Eel River, consisting of a complicated array of alternatives (discussed under the Upper Eel Development section). Phase Two is the Trinity Diversion Development on the Trinity River below Lewiston Reservoir: consisting of Helena Dam and Reservoir, a possible Schneiders Bar Dam and Reservoir and the needed conveyance facilities. Phase Three is the South Fork of the Trinity Development, consisting of Eltapom Dam and Reservoir. Phase Four is the Mad-Van Duzen Project, consisting of the Enlarged Ruth Dam and Reservoir, the Eaton Dam and Reservoir, the Larabee Dam and Reservoir, the Anderson Dam and Reservoir, plus all necessary conveyance facilities. Phase Five is the Lower Eel River Development consisting of a Sequoia Dam and Reservoir, a Bell Springs Dam and Reservoir, the relocation of 100 miles of Northwestern Pacific Railroad's track from the Eel River Canyon to a protected site, and the needed conveyance facilities. Phase Six is the Klamath River Development consisting of Humboldt Dam and Reservoir, a possible Ironside Mountain Dam and Reservoir, and the needed conveyance facilities. Of course these phases are subject to revision and do not consider numerous structures which would have to be built in the Sacramento River Basin for transportation of the water throughout California.

5. Construction Timetable

We must emphasize here that this Six Phase program has *not* been authorized and funded, and is regarded by DWR as "Possible Future." The building schedule for these phases had not been established as of February, 1971. Department of Water Resources *Bulletin 160-66*, published March 1966, states that the water from the first structures to be built – the Upper Eel River Development – will not be required until the mid-1980's (28). The Department of Water Resources *Bulletin 160-70* published December 1970 suggests that Eel River water will not be required until about a decade later during the mid-1990's (29). In part, this stems from lower population projections for the State.

But these schedules are required if the reservoirs should be deemed necessary. For example: the proposed Dos Rios Dam, intended to dam the upper Middle Fork of the Eel as part of Phase One, has thirteen years planned as the time allotment needed for its construction (30). Some of the other proposed reservoirs and conveyance systems would take longer to build.

Building schedules will be established when a foreseeable water need is projected which the current facilities could not handle and the next phase is then authorized for inclusion into the State Water Project.

Table 4-5

Summary of Possible Major Export Projects in North Coastal Area

Project & Principal Features	Project Annual Yield (1,000 A.F.)	Estimated Capital Cost ($1,000,000)
PHASE ONE		
Upper Eel River Development (via Clear Lake)		
Spencer Dam & Reservoir	470	55
Dos Rios Dam & Reservoir	110	25
English Ridge Dam & Reservoir	340	80
Putah Creek Power Facilities	- -	32
Conveyance Facilities*	- -	106
Total	920	298
PHASE TWO		
Trinity Diversion Project (via Clear Creek)		
Helena Dam & Reservoir	600	84
Conveyance Facilities*	- -	70
Total	600	154
PHASE THREE		
South Fork Trinity Project		
Eltapom Dam & Reservoir	400	55
Burnt Ranch Dam & Reservoir	80	71
Beartooth Dam & Reservoir	120	14
Clear Creek Power Facilities	- -	164
Conveyance Facilities*	- -	56
Total	600	360
PHASE FOUR		
Mad-Van Duzen Project		
Enlarged Ruth Dam & Reservoir	180	13
Anderson Ford Dam & Reservoir	60	30
Eaton Dam & Reservoir	230	26
Larabee Dam & Reservoir	130	37
Butler Valley Dam & Reservoir	- -	13
Conveyance Facilities*	- -	101
Total	600	220
PHASE FIVE		
Lower Eel River Development		
Sequoia Dam & Reservoir	600	170
Bell Springs Dam & Reservoir	400	101
Northwestern Pacific Railroad Relocation	- -	130
Conveyance Facilities*	- -	186
Total	1,000	587
PHASE SIX		
Klamath River Development		
Humboldt Dam & Reservoir	6,000	652
Ironside Mtn. Dam & Reservoir	- -	11
Westside Conveyance System	- -	130
Rancheria Dam & Reservoir	200	90
Conveyance Facilities*	- -	637
Total	6,200	1,520

*A major part of Conveyance Facilities costs is for tunnels.

(Adapted from Department of Water Resources, *Bulletin No. 136*.)

6. Predictions

It is difficult to accurately predict what would happen to the environment, fish, and wildlife if the proposed State Water Project diversion developments were to be constructed in the North Coast Area. Too little money and too little research have been applied to making sound predictions. Below are listed the reports attempting to predict the consequences of the State Water Project construction in the North Coast Area:

Problems and Study Requirements in Relation to North Coast Water Developments (1966)

North Coastal Area Investigation (1964)

Sediment Yield and Land Treatment: Eel and Mad River Basins. Appendix I (1970)

Preliminary Report on the Impact of the Trinity River Development on Fish and Wildlife Resources (1970)

Middle Fork of the Eel River Development: The Effects of Middle Fork on the Eel River Developments on Wildlife Resources (1969)

An Evaluation of the Fish and Wildlife Resources of the Mad River as Affected by the U.S. Corps of Engineers' Mad River Project with Special Reference to the Proposed Butler Valley Reservoir.

Data and generalizations from all except the last are included in the present report. Obviously, much more research of the depth of the excellent Middle Fork report must occur if the public is to know what the environmental and wildlife costs of the proposed projects would be.

7. Suppressed Report

However, this information must continually be made public in order for the people to decide if they are willing to accept the environmental consequences of the State Water Project. The Department of Fish and Game has not been making such reports public. The excellent Trinity River Development report would not be available to the public today if the California Committee of Two Million (a conservation group dedicated to opposing construction of the State Water Project in the North Coast Area) had not sued the California Department of Fish and Game in the Trinity County Superior Court to release the suppressed report, which outlines the expected effects of the proposed Trinity River developments on the local fish and wildlife (31). Fortunately, the judge ordered the report released.

III. Analysis of the Six Phases of the State Water Projects Proposed North Coast Development.

A. The Upper Eel River Development

1. Area Description

Sucking an average runoff of 6.3 million acre feet from over 3,700 square miles of rugged valleys, v-shaped canyons, flood plains, gravel flats, and redwood and Douglas Fir forests that reach from sea level up to 4,000 feet, the Eel River is the most southerly of the three North Coast River systems which might be tapped for water (32, 33).

The Eel River system returns an annual average of 69,000 king salmon, 30,000 silver salmon and 115,000 steelhead to their birth places for spawning (34). Numerous black-tailed deer, waterfowl, upland game, and furbearers live along the river system and back into the canyons which trap the water for the river. These fish and wildlife live in a unique geological area.

The Franciscan Group underlies the Eel River Drainage, as well as most of the Van Duzen and the Mad River drainages. The Group is an intensely faulted, folded, brecciated, and sheared assemblage of sedimentary and volcanic rock interlaced with fingers of serpentine rock (35). This Group is responsible for making the ground under the proposed dam sites "the poorest in the State"(36). The tunneling rock is equally as poor (37). But the feature which makes this region so unique is the large quantity of sediment which flushes through the Eel River system. The Eel has the highest average sediment yield of any river of comparable size in the United States (38).

2. Upper Eel River Development

The sediment flows equally strong in the North Fork, the South Fork and the Middle Fork. But it is the Middle Fork of the Eel River that might be the site of the first State Water Project dam to be built after the now-completed Oroville Reservoir. On March 9, 1964, the Director of Water Resources signed Project Order No. 7 authorizing the upper Eel River Development as an additional facility of the California State Water Project (39). In January, 1969, the Assembly Water Committee and the Senate Committee on Water Resources made favorable reports on the proposed Upper Eel River Development projects (40). But conservation groups and Indian sympathizers raised loud opposition to one facet of the proposed Development – the Dos Rios Project.

3. The Dos Rios Project

The proposed Dos Rios Project had two alternative plans on the drawing board: 1) A large (1,700 foot) dam on the Upper Middle Fork of the Eel River and Dos Rio Reservoir with the Grindstone Tunnel diverting water from Dos Rios to the Sacramento Basin; or 2) a large Dos Rios reservoir, a Dos Rios-Willis Ridge Tunnel diverting water from Dos Rios to the proposed Willis Ridge Reservoir on the main Eel River, and a Garret Tunnel which would divert water from the Willis Ridge Reservoir to the Clear Lake Drainage

(41). Both alternatives intended to flood Round Valley and the town of Covelo and would have forced the evacuation of the local Indians from Round Valley.

In response to the public uproar, Governor Reagan announced his displeasure with the consequences of the proposed Dos Rios project, and on May 13, 1969, he asked for a study of project alternatives (42). On November 14, 1969, Governor Reagan asked the Army Corps of Engineers to cease their initial Dos Rios planning (43). The requested alternatives were presented in January, 1970, in the form of the Department of Water Resources *Bulletin No. 172*, entitled, *Eel River Development Alternatives Appendix, Supporting Studies*. In December, 1969, the California Department of Fish and Game published *The Effects of Middle Fork Eel River Development on Wildlife Resources*.

In June, 1970, the Soil Conservation Service and the California Department of Water Resources published its limited report on sediment yield and land treatment: *North Coastal Area of California and Portions of Southern Oregon, Appendix I, Sediment Yield and Land Treatment, Eel and Mad River Basins*. By June, 1970, the public was presented with material which outlined proposed alternatives for Upper Eel River Development, a scant flurry of suggestions on what might happen to the Eel below the proposed dams if they were built, and an excellent report by a consulting biologist on the possible effects to the local wildlife if the Dos Rios Reservoir were constructed. There is, however, no comprehensive report on the predicted effects of the Upper Eel River Development on fish and wildlife in the area (44).

4. Upper Eel River Development Alternatives

Three basic alternatives were presented in *Bulletin No. 172*:

1) A small Dos Rios Reservoir (with a 1,300-foot dam, which would not flood Round Valley, and accessory reservoirs);

2) A Medium Dos Rios Reservoir (with a 1,600-foot dam) with provisions to protect Round Valley; and

3) A large Yellow Jacket Reservoir on the lower Eel River.

Since the Upper Eel River Development has been designated as part of the State Water Project, one of the alternatives probably will be constructed unless serious opposition develops.

5. Predicted Effects on Fish

If the reservoir or reservoirs were to be constructed, they would have a serious effect on the aquatic environment and on the fish and wildlife of the Upper Eel River area. The reservoirs would release higher than normal summer flows. This would affect 133 miles of river below the proposed English Ridge Reservoir, 125 miles of river below the proposed Willis Ridge Reservoir, and 59 miles of river below the proposed Yellow Jacket Reservoir (45). If the released waters were not dangerously silty, the higher releases could increase the summer steelhead run and stabilize the river environment for resident trout and other fish.

The annual releases would be low, however, and the Department of Fish and Game report suggests that the following will happen:(46)

1. Presently the Eel River has enough flow to flush the sediments and debris which enter the river from logging, road construction, sheet erosion and tributaries. If a reservoir is built on the Eel, the river would not be able to flush this invading matter.

2. Coarse material would settle out at the confluence of the river with the tributaries. The channels would aggrade upstream, reduce the stream gradient, and decrease sediment-carrying capacity.

3. Fine material would settle out; smothering spawning gravel and its biota and encourage riparian vegetation (such as willows and cattails) and aquatic vegetation to invade the now barren river bottomland.

4. The releases might not be strong enough to counteract the flow from large tributaries, and tributaries entering at an angle could cause instability and erosion along the main river.

Since the proposed Middle Fork dams would block the annual upstream migrations of at least 9,000 king salmon and 17,000 steelhead, the fish would be forced to spawn in the waters below the proposed reservoirs (47, 48). Undoubtedly this would force a decrease in the anadromous fish populations of the Middle Fork of the Eel River. However, it is suggested in *The North Coastal Area Investigation (1964)* that the current runs of fish could be maintained by 1) the construction and operation of fish hatcheries and artificial spawning channels, 2) improving the natural spawning opportunities below the proposed dams, 3) releasing controlled flows from the dams to the advantage of the fish, 4) releasing the controlled flows through a multilevel series of pipes in order to maintain the proper stream temperature below the dams, and 5) by protecting the migrating fish during construction (49).

These measures have been tried below the Lewiston and Trinity reservoirs, which have already been built on the Trinity River. Unfortunately, they have not worked, and the biologists do not know why. They believe that it will be impossible to preserve the ancient anadromous fish runs on the Trinity River on the basis of present knowledge (50). The same might happen on the Eel River below the proposed Upper Eel River Development.

6. Predicted Effects on Wildlife

The proposed developments would also seriously affect the local wildlife if the projects were completed. If the old proposed Dos Rios Dam (with its 1,700-foot dam) were to be constructed, the following would probably occur: (51, 52)

1. A total of 49,629 acres would be flooded and permanently lost for wildlife habitat. The rare Riparian habitat (487 acres) and the Valley-Hardwood habitat (2,283 acres) would be eradicated.

2. Since anadromous fish no longer would be abie to spawn in the wild upper reaches of the Middle Fork of the Eel River, the black bears and bald eagles which depend on their presence for food will be seriously harmed.

3. Wildlife that is dependent on the spray of falls (such as the water ouzel) would be nearly eradicated.

4. A local population of 1,600 black-tailed deer would be exterminated.

5. About 3,365 valley quail would be eliminated.

6. Small mammals, upland game, fur-bearers, smaller birds, migratory waterfowl, lesser wildlife and the plants of the Lower Eel River Basin and the forks and tributaries of the Eel will be affected by the destruction of habitat and shifting of populations to new areas.

7. Most of the song birds and the small mammals would be killed and the migratory band-tailed pigeons would be potentially endangered as the major stands of the valley hardwood is flooded.

A similar tragedy would occur if the 1,600-foot dam were to be built (53). 40,126 acres would be flooded (54).

The small Dos Rios Dam proposition (with a 1,300-foot dam) would flood 4,250 acres. While it would be the least harmful to the local wildlife, it would seriously affect the animals dependent on having the river flowing free – the anadromous fish, the black bears, the bald eagles, and the water ouzel. Numerous small birds and animals would also be affected. One must remember that if the small Dos Rios Reservoir is constructed, either Spencer or Minas reservoirs would also be constructed, with a loss of 3,700 flooded acres if Spencer is built and 3,200 acres if Minas is built (55).

7. Landslide Problems

No matter which reservoirs are built, there would be constant problems with the landslides which would be expected for the first years of reservoir stabilization (56). Landslides are common in the Upper Eel Drainage, as well as throughout the North Coast Area. Since the proposed reservoirs probably would have rock-filled construction, they could not withstand much overtipping if a big slide crashed into their waters (57).

B. The Trinity River Development

1. Area Description

Born amidst the alpine crags and snowfields of the Trinity Alps, the Trinity River drains 3,000 square miles as it pushes westward to the sea. Steep-sided canyons, valleys, and wildernesses border and hide its path. Fishermen and hunters come to enjoy its abundant game and fish. Lumbermen roar along Highway 299 as the road tries to follow the tortuous river and fails.

The river is not virgin. It has been dammed twice, with roughly 850,000 acre feet of Trinity River water annually diverted to the Sacramento River above Redding (58). Trinity Reservoir was completed in 1962 and has a surface area of 16,000 acres (59). Being used for power generation and agricultural water supply, the lake is subject to seasonal drawdowns. Lewiston Reservoir is the Trinity Reservoir forebay. With 610 surface acres and a duty to re-regulate Trinity Reservoir (officially designated Clair Engle Reservoir but called Trinity Reservoir by the locals), Lewiston is a small stable reservoir – an excellent trout-fishing lake (60).

2. Trinity River Model

Thanks to the two reservoirs, the California Department of Fish and Game and other interested observers have a working model which should accurately predict what would happen to the rest of the Trinity River Development project and other phases of the State Water Project would be constructed.

One aspect of the model is the Trinity River Fish Hatchery below Lewiston Reservoir. Completed in 1963, the hatchery has had many problems trying to maintain anadromous fish runs blocked from their spawning grounds by the two dams; other hatcheries would probably face similar problems.

Particularly troublesome has been the maintenance of suitable hatchery water temperatures. The winter hatchery water temperatures are too low, and only 15% of the steelhead fry reach desirable size after a year's residence at the hatchery (61).

Another problem has been turbidity. Since it takes silt and debris longer to flush from reservoirs than the pre-dam river, winter outflows from Trinity and Lewiston reservoirs are often turbid long after the old river would have cleared (62). Hatchery fish do not thrive in turbid water.

If the Trinity River Fish Hatchery were not one of the most modern in the world then one could blame hatchery design and technique on the reduced runs of anadromous fish which now enter the fish ladders at the hatchery. The California Department of Fish and Game, the Bureau of Sport Fisheries and Wildlife, and the U.S. Bureau of Reclamation teamed to design the hatchery operations and facilities. The U.S. Bureau of Reclamation constructed the hatchery and pays all of its costs. The California Department of Fish and Game runs it. The hatchery is large enough to produce and handle the fry of up to 35,000 salmon and steelhead annually (63)

But 35,000 anadromous fish do not arrive at the hatchery ladders begging for entrance. Of the 12,000 king salmon and 10,000 steelhead which annually spawned in the Trinity River above the hatchery, only

3,899 adult king salmon and 554 steelhead were spawned in the multi-million-dollar hatchery from July 1, 1968 to June 30, 1969 (64) (See Table 4-6 for the decreasing king salmon and steelhead runs which arrived at the Trinity Fish Hatchery between July 1, 1959 and March 7, 1970.) The situation is so desperate that

Table 4-6

Salmon and Steelhead Runs at Trinity River Hatchery

	King Salmon			Silver Salmon			Steelhead
July 1 thru June 30	Grilse[1]	Adult	Total	Grilse	Adult	Total	
1959-1960	2,701	4,549	7,250	26	93	119	2,071
1960-1961	4,130	2,780	6,910	70	138	208	3,526
1961-1962	2,899	2,498	5,397	37	318	355	3,243
1962-1963	6,535	2,916	9,451	9	7	16	1,687
Trinity Reservoir Completed							
1963-1964	2,535	4,200	6,740	11	72	83	894
1964-1965	1,287	5,016	6,303	2	48	50	6,941
1965-1966	1,521	1,554	3,075	9	3	12	992
1966-1967	2,786	2,054	4,840	807	218	1,025	135
1967-1968	1,746	2,807	4,616	59	806	865	232
1968-1969	873	3,899	4,772	34	4	38	554
1969-1970 (to 3-7-70)	1,130	1,456	2,586	1,703	281	1,996	170

[1] Sexually immature salmon

(Adapted from Department of Fish and Game, *Preliminary Report*.)

two holding ponds are reserved for raising brooder steelhead to supplement the present runs and to prepare for the possible day when no steelhead will return.

Thus, despite the finest application of fisheries science at the Trinity River Fish Hatchery, the hatchery has not proved to be an adequate solution to the problem of maintaining runs of anadromous fish that are blocked from their ancestral spawning grounds. The fisheries biologists cannot explain the decline. But one thing they are firm about: the past runs on the Trinity River cannot be maintained on the basis of modern fisheries science (65).

Not all of the fish which used to swim up the Trinity stayed to spawn above the two dams. A few king salmon still spawn in the gravel flats in Hoopa Valley, a few miles upstream from the confluence of the Trinity and Klamath Rivers. But most of the kings spawn in the forty miles between the junction of the North Fork of the Trinity River with the main Trinity River and the Trinity River Fish Hatchery, in a few

tributaries, or in the wild and undisturbed South Fork of the Trinity River: only 50% of the spawning area which existed before the dams (66). The steelhead usually spawn in the same areas.

But these spawning fish are rapidly being pushed out the sixteen-mile stretch of water from the Trinity River Fish Hatchery downstream to Douglas City. Since 1963, 28% of the king salmon spawning area in this stretch has been spoiled by sedimentation – at an estimated annual loss of 14,000 harvestable salmon (67).

Since the construction of the two reservoirs, the annual flow of the Trinity River has been decreased by 88% and the peak flows have decreased from 70,000 cubic feet per second to 250 cubic feet per second (68). The former wild and fluctuating river has been tamed to a small and stable stream. No longer do high flows flush sediments from the gravel and sand bottoms, clean and renew gravel for spawning beds, prevent compaction of spawning gravel, and retard riparian and aquatic vegetation (69). With such diminished flow rates, the water easily warms to the mid-70^{o}s, a few miles downstream from Lewiston Dam in the summer (70).

Not all animals and ecosystems are worse off because of the changes in the environment wrought by the Upper Trinity River Development. The waterfowl population has waxed fat and large on the abundance of aquatic vegetation which now exists in the Trinity River below Lewiston and in Lewiston Reservoir (72).

The animals which used to live on the 117,110 flooded acres of habitat that is now divided into Trinity and Lewiston Reservoirs – probably were not as lucky as the waterfowl. But no one knows for sure what happened to the California quail, black bears, mountain quail, band-tailed pigeons, sooty grouse, gray squirrels, the 4,000 to 6,000 black-tailed deer and the other wildlife which once lived there (72, 73). After looking at the report on the projected effects of the Dos Rios Reservoir, one can assume that a large number of animals were seriously affected.

3. The Trinity Diversion Project

If the Upper Eel Development is constructed, and the people of California decide that they need more water, then the Trinity Diversion Project might be constructed. The project consists of Helena Dam and Reservoir, a possible Schneiders Bar Dam and Reservoir, and the necessary conveyance facilities.

The proposed Helena Reservoir would be constructed forty miles downstream from Lewiston Reservoir, and its tail would lap near the base of Lewiston Dam. The Reservoir would have a capacity of 2.8 million acre feet and a surface area of 15,574 acres (74). The dam would probably be made with the excellent gravel which abounds in the river channels and the quality rockfill which is easily quarried along the Trinity River (75). Obtaining these materials would present potential silt pollution problems similar to those posed while Box Canyon Dam was being constructed on the Sacramento River above Lake Shasta.

Another problem would be handling anadromous fish which now spawn at or above the proposed reservoir sites. The proposed Helena Reservoir would prevent access to the spawning areas below Lewiston Reservoir and the North Fork of the Trinity River. The only hope for salvaging these runs would be to build a fish hatchery, one which would be larger than the present Trinity River Hatchery, as it would be

responsible for maintaining a large run of fish. In all large hatcheries, however, disease would be a problem (76). And the proposed reservoir would raise greater fisheries problems than those still unsolved in the Upper Trinity Development (77). Most likely the anadromous fish which now run above the proposed Helena Dam site would be destroyed unless solutions to the type of hatchery problems faced at the Trinity River Fish Hatchery are discovered. But these solutions cannot be developed without additional funding for research (78).

Unless outflows are handled differently at the proposed Helena Reservoir, the first twenty miles of river below the dam will resemble the Trinity below Lewiston today, with siltation, spawning gravel compaction, low flows, temperature problems, and turbidity affecting the aquatic life in the river.

The reservoir above would have little fish life. A five-pounds-per-surface-acre-per-year fish yield is projected (79). Helena would provide a sparse warm water and cold water fishery, and periodic stocking would be required to maintain the trout fishery. "There would be no way to flly compensate for the loss of ninety miles of highly prized saimon and steelhead fishing area."(80)

There would be no way to compensate for the loss of the black-tailed deer which would be forced from the Trinity River bottomlands, one of the only areas where the deer can feed during the winter (81). The deer herd present after the completion of Helena and Schneiders Bar reservoirs probably would be directly proportional to the amount of winter browsing area destroyed.

The wildlife which depend upon the free-flowing stream also probably would be killed in direct proportion to the inundation of suitable river habitat. Beaver, mink, water ouzels and river otters would have to find new places to live or perish.

If the Schneiders Bar Reservoir is constructed, the same problems which we have discussed in connection with Helena Reservoir would arise – except that fishery mitigation would be more difficult (if not impossible) in the sheer canyons bordering the river below the proposed dam site (82). No hatchery location has been decided upon for the region below the proposed Schneiders Bar Dam (83). If one were built below the proposed dam, it would be intended to compensate for the fishery losses incurred with the development of the main Trinity and the South Fork of Trinity. The hatchery would be forced to attempt to maintain roughly 80,000 steelhead, 6,000 silver salmon, 55,000 king salmon, and the few sea-run brown trout which would be prevented from spawning in the two forks of the Trinity River (84).

C. The South Fork of the Trinity Development

If a water need is projected after the completion of the Trinity Diversion Project, the South Fork of the Trinity River Diversion Project would be the next water transport facility to be authorized. The project consists of Eltapom Dam and Reservoir, Burnt Ranch Dam and Reservoir, Beartooth Dam and Reservoir, Clear Creek Power Facilities, and the required conveyance network (85). The water collected by Eltapom from Beartooth Reservoir on the New River and from the flow of the South Fork of the Trinity River would be diverted to the proposed Schneiders Bar Reservoir, back-pumped to Helena Reservoir, and then shot through the Clear Creek Tunnel No. 2 to the Sacramento Basin (86).

If the project should be completed, the projected effects described for Helena and Lewiston reservoirs and surrounding areas would probably occur. In addition, 90 of the 165 miles of the main Trinity River and the South Fork of the Trinity River now enjoyed by slamon and steelhead fishermen would be flooded. The anadromous fish runs would be largely destroyed (87). The development would also seriously affect the aquatic and riparian ecology of the remaining seventy-five miles of canyon-bound river below the South Fork of the Trinity Project (88).

D. The Mad-Van Duzen Project

1. Area Description

Twisting through the foggy redwood belt north of the main Eel River is the sedate Van Duzen River. Draining 497 square miles of redwood country and the low mountains to the east, the Van Duzen contributes one million acre feet of annual runoff to the lower Eel River (89). From its origins in the mountains of southwest Trinity County to its entrance into the Eel River fifteen miles upstream from the ocean, the Van Duzen is a widely fluctuating river. It depends upon heavy rains to swell its lean summer trickle. Roughly 3,000 king salmon, 1000 silver salmon and 7,000 steelhead spawn in the Van Duzen's lower U-shaped valleys and upper V-shaped canyons (90).

The Mad River twists in the same setting as the Van Duzen, which lies over a small ridge to the south. The Mad nurtures slightly more anadromous fish than the Van Duzen: 1000 king salmon, 2,500 silver salmon, and 6,000 steelhead spawn in the Mad annually (91). Anglers know that the fish are there and avidly fish this river.

2. Project Description

The Mad-Van Duzen Project comprises Phase Four, which would be built after the preceding three phases, if water needs remain in other parts of the State. The Mad-Van Duzen Project is a large one. It consists of 1) Larabee Dam and Reservoir, which would be constructed on the upper South Fork of the Van Duzen River; and 2) Eaton Dam and Reservoir, which would be built over the major spawning grounds on the upper North Fork of the Van Duzen River; 3) the proposed Anderson Ford Diversion Reservoir on the upper Mad River; 4) a tunnel between Anderson Ford Reservoir and Eltapom Reservoir; 5) a Butler Valley Reservoir and Dam on the lower Mad River, which would be used to supply water to the Eureka-Arcata area; and 6) an enlarged Ruth Reservoir on the upper Mad River.

The project would add roughly 600,000 acre feet of water annually to the State Water Project at a projected cost of $220 million (92).

3. Landslide Problems

As with the developments on the forks of the Eel River, the proposed dam sites on the Mad and Van Duzen rivers rest upon the fractured Franciscan Group. Landslides and siltation would be expected in the

reservoirs, and the water exiting from the reservoirs probably would be turbid.

4. Fisheries Problems

The dams would block thousands of steelhead and salmon from spawning. The same problems with raising anadromous fish and maintaining a natural stream flow below the proposed dams as occurs on the Trinity River could occur, thus destroying much of the salmon and steelhead runs now enjoyed for the first several miles below and all of the miles above the proposed reservoirs.

5. Wildlife Problems

There are no reports commenting on the expected consequences of the proposed dams on the local wildlife.

E. The Lower Eel River Development

If after the constructions of the Upper Eel River Development (Phase One), the Trinity Diversion Project (Phase Two), the South Fork of the Trinity River Project (Phase Three), and the Mad-Van Duzen Development (Phase Four), and the proper Sacramento Basin conveyance systems, and if Californians believe that they need more water, then the Lower Eel River might be developed (93). Water requirements would have to be drastic before this project would be authorized, as it would be expensive and would have very serious drawbacks.

Sequoia Dam and Reservoir, Bell Springs Dam and Reservoir and the needed conveyance facilities constitute the Lower Eel River Development. Sequoia Reservoir would be constructed about ten miles upstream of the confluence of the main Eel River with the South Fork of the Eel River. The water from Sequoia would be backpumped to Bell Springs Reservoir, which would lie five miles upstream from the junction of the main Eel River, with the North Fork of the Eel River. The water from Bell Springs Reservoir would be backpumped to the Dos Rios Reservoir and then over the mountains to the Sacramento Basin (94).

There are three main problems in this proposed development of the Lower Eel River: 1) anadromous fish which spawn on the Middle Fork of the Eel River would be flooded out; 2) wildlife would be flooded from their habitat; and 3) one hundred miles of the Northwestern Pacific Railroad (which transports 80% of the finished wood products from the Humboldt Bay Area) would have to be moved from the Eel River canyons and routed elsewhere at a cost of $130 million (95).

No comprehensive reports have been issued predicting the effects of the proposed developments on the fish and wildlife of the region.

F. The Klamath River Development

1. Area Description

If all else fails, the Klamath River could be tapped for its immense flow of water. Originating in Oregon and prying through a 15,700-square-mile drainage area (with 5,695 square miles in Oregon), the Klamath is the pathway for an annual runoff of roughly 12 million acre feet – 40% of the runoff of the North Coast area (96).

The Klamath is also the pathway for the largest steelhead run in the world. As many as one million of these fish (four times the steelhead run in the Sacramento River) annually ascend the frothing Klamath on their spawning journeys (97). An average of 175,000 king salmon and 20,000 to 70,000 silver salmon also use the river during their annual spawning runs (98).

The fish are halted on their upstream migration by Iron Gate Dam, which lies upstream of Highway 97. As a consequence, the salmon spawn mainly in the first three miles below the dam, while the steelhead and silvers spawn there and in the tributaries. The fish are joined by spawning shad, sturgeon and candlefish. As of 1966 this river was contributing roughly $20 million per year to the local recreational and commercial fisheries industries (99)

2. Project Description

The California taxpayers would contribute at least $1.6 billion (1964 estimated cost) to dam the Klamath River with the proposed Humboldt Dam and provide the necessary conveyance network to get the water through the rugged mountains to the Sacramento Basin (100).

Constructed about twelve miles upstream from the junction of the Klamath River and the Trinity River, Humboldt Dam would have a capacity of 15 million acre feet and would deliver at least 6 million acre feet of water annually to the Sacramento Basin (101). Water might be backpumped from Humboldt Reservoir to the seldom-mentioned Iron Mountain Reservoir on the Lower Trinity River, from there to Burnt Ranch Reservoir, and then through tunnels to the Sacramento Basin.

The final project that would be constructed is the proposed Ah Pah Reservoir, which would be constructed several miles upstream from the Pacific Ocean. It would only intensify the problems caused by the proposed Humboldt Reservoir and would leave a few miles of estuary and free-flowing river in the Klamath River Drainage.

3. Fish, Wildlife, and Other Problems

The proposed development would create three major problems on the Klamath River: 1) they would probably eliminate the anadromous fish runs in the Klamath River and Trinity River by blocking these fish from their nursery grounds, 2) the sport fishery for salmon and steelhead would be destroyed in these two rivers; and 3) the wildlife which depends on the river bottomlands for existence (the furbearers, the wintering deer, and the waterfowl) would be flooded out of their environment and possibly eliminated (102).

A hatchery which could maintain even a run of 400,000 adult salmon annually would "be out of the question on the basis of existing fish culture practices." (103)

An additional problem would develop if Iron Mountain Reservoir should be constructed. The Indians at Hoopa Valley, located on the lower reaches of the Trinity River, would have to be relocated when the proposed reservoir flooded their valley.

G. Conclusions

The water diversion projects which are proposed for construction on the Eel, Trinity and Klamath River drainages in the North Coast Area of California pose potential threats to the fish and wildlife of the Area, as well as to the local economy, sportsmen, and vacationers.

If the projects which We have outlined were to be constructed, the anadromous fish would face problems with increased siltation, turbidity, spawning gravel compaction and cementation, and decreased water flow. Various state and federal agencies might attempt to mitigate the consequences of these problems with 1) the construction and operation of fish hatcheries and artificial spawning channels: 2) stream enhancement below the proposed dams: 3) controlled releases of water advantageous to the fish; 4) multilevel release valves on the proposed dams to provide water of optimum temperature for the downstream fish: and 5) interim provision of anadromous fish during the projects' construction (104).

The most suitable methods have been attempted on the Trinity River below Lewiston Reservoir and Table 4-6 shows that they have failed to maintain the runs of steelhead and salmon. It is possible that future attempts would be similarly unsuccessful.

Wildlife also would have serious problems if the proposed structures were built. Black-tailed deer would be forced from their winter browsing areas along the low river valleys and on the low south slopes above the rivers, and biologists could do nothing to keep them from reducing their population to the new holding capacity of the area through starvation and death and from attempting to swim across the proposed reservoirs over their ancestral migration routes (105).

The deer would not be the only wildlife affected. The stream-associated species (mink, otter, beaver, bald eagles and black bears) might be eliminated. Other small mammals and song birds would be affected by the changes wrought. Waterfowl would decrease in the poor environment that the fluctuating reservoirs would provide for them. Upland game would be forced out of their stream-side habitats. Much more money and research must be expended to find the projected environmental, fish, and wildlife costs of these projects.

Recreation is expected to be the number one industry in the North Coast Area once the lumber producers are operating on a sustained yield basis, which should not be too far in the future (106). Water-associated recreation in the North Coast Area could jump from the present 218 million visitor days to 2.5 billion visitor days by 2020 (107). Even during 1964 the demand for fishery resources provided by the three river drainages by recreational and commercial interests was greater than the supply (108). This demand is certain to increase. Will the sterile warm water fisheries of the proposed reservoirs be adequate to meet this demand?

The California Department of Fish and Game has been assured of receiving adequate stream flows and reservoir levels to protect and improve fishery, wildlife, and recreational features along the potentially affected North Coast rivers (109). But even with such guarantees in force on the Trinity River below Lewiston Reservoir, enormous changes and damage have been forced on the fish, wildlife and aquatic environment along the first sixteen miles below Lewiston. It is possible that the same types of changes and damage would be thrust upon other stretches of the rivers if any of the proposed dams were built.

Even if the State Water Project does not dam all of the rivers that we have just discussed, the North Coast Rivers could still be affected after September 30, 1978, when the Secretary of the Interior will introduce the Western United States Water Plan (110). This project will propose water diversion from Northwestern United States to the Southwest. The Eel, Trinity, and Klamath River drainages and numerous coastal streams in the North Coast Area might once again be eyed with water diversion in mind.

FOOTNOTES

1. For a description of the decision behavior of individuals in both equal strength and unequal strength situations of economic conflict, see L. Fouraker and S. Siegel, *Bargaining Behavior* (McGraw-Hill, New York, 1963).

2. That costless bargaining will result in the resource allocation representing the least cost to society irrespective of initial placement of legal rights was pointed out by R. H. Coase. R. Coase, *Journal of Law and Economics*, Vol. 3 (1960), p. 1. The same type of argument was presented by J. Buchanan and W. Stubblebine, *Economics*, Vol. 29 (1962), p. 371.

3. Edwards, *Natural Resources Lawyer*, Vol. 1 (1968), pp. 58-67.

4. The benefits of a tax system for the control of pollution from stationary sources of air pollution are discussed by E. Mills in *The Economics of Air Pollution*. H. Wolozin, Ed., (New York: W. W. Norton, 1960), p. 40.

5. State of California, The Resources Agency, Department of Water Resources. *Bulletin No. 160-66: Implementation of the California Water Plan*, 1966.

6. - - -. *Bulletin No. 160-70: Water For California. The California Water Plan. Outlook in 1970*, 1970.

7. *Ibid.*, p. 1.

8. *Ibid.*, p. 155.

9. - - -. *Bulletin No. 160-70: Water For California. The California Water Plan. Outlook for 1970. Summary Report* 1970, p. 35.

10. - - -. *Bulletin No. 160-70: Water For California. The California Water Plan. Outlook for 1970*, 1970, p. 152.

11. State of California, The Resources Agency. Department of Water Resources, *Bulletin No. 136: North Coastal Area Investigation*. Preliminary edition. September. 1964, p. 16.

12. *Ibid.*, p. 19.

13. *Ibid.*, p. 45.

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18. *Ibid.*, p. 28.

19. Department of Water Resources, *Bulletin No. 136*. p. 37.

20. State of California. The Resources Agency. Department of Water Resources, *Bulletin No. 160-70: Water for California, The California Water Plan Outlook in 1970*. December, 1970. p. 66.

21. Department of Water Resources. *Bulletin No. 136*. p. 45.

22. *Ibid.*, p. 45.

23. *Ibid.*, p. 126.

24. *Ibid.*, p. 45.

25. *Ibid.*. p. 36.

26. *Ibid.*. p. 34.

27. State of California. The Resources Agency, Department of Water Resources. *Bulletin No. 132-70. The California State Water Project in 1970.* 1970. p. 8.

28. ---. *Bulletin No. 160-66. Implementation of the California Water Plan.* March, 1966. p. 106.

29. ---. *Bulletin 160-70*. p. 5.

30. ---. *Bulletin No. 172: Eel River Development Alternatives. Appendix. Supporting Studies.* January, 1970. p. 15.

31. California Committee of Two Million. *Wild Rivers Reporter*. Vol. 1 No. 1. Summer, 1970. p. 3.

32. Department of Fish and Game. *Fish and Wildlife Problems*. p. 33.

33. Department of Water Resources. *Bulletin No. 136*. p. 20.

34. *Fish and Wildlife Problems*, p. 34.

35. Department of Water Resources. *Bulletin No. 136*. p. 40.

36. *Ibid.*. p. 40.

37. *Ibid.*. p. 42.

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41. Department of Water Resources. *Bulletin No. 172*. pp. 12, 18.

42. *Ibid.*, p. iii.

43. Department of Water Resources. *Bulletin 132-70*. p. 8.

44. Department of Water Resources. *Bulletin No. 172*.

45. *Ibid.*, p. 6.

46. Department of Fish and Game. *Fish and Wildlife Problems*.

47. *Ibid.*, p. 34.

48. Department of Water Resources. *Bulletin No. 136.* p. 134.

49. *Ibid.*, p. 134

50. Department of Fish and Game. *Preliminary Report.* p. 4.

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54. *Ibid.*, p. 56.

55. Department of Water Resources. *Bulletin No. 172.* pp. 40, 46.

56. Department of Water Resources. *Bulletin No. 136.* p. 119.

57. *Ibid.*, p. 42.

58. *Ibid.*, p. 86.

59. Department of Fish and Game., *Preliminary Report.* p. 14.

60. *Ibid.*, p. 14.

61. *Ibid.*, p. 23.

62. *Ibid.*, p. 18.

63. State of California, The Resources Agency, Department of Fish and Game., *Trinity Salmon and Steelhead Hatchery.* Pamphlet.

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65. *Ibid.*, p. 4.

66. Department of Fish and Game. *Fish and Wildlife Problems.* p. 39.

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68. *Ibid.*, p. 18.

69. *Ibid.*, p. 18.

70. *Ibid.*, p. 18.

71. *Ibid.*, p. 21.

72. *Ibid.*, p. 15, 18.

73. Department of Fish and Game. *Fish and Wildlife Problems.* p. 67.

74. Department of Fish and Game. *Preliminary Report.* p. 29.

75. Department of Water Resources. *Bulletin No. 136.* p. 41.

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77. *Ibid.*, p. 4.

78. *Ibid.*, p. 3.

79. *Ibid.*, p. 43.

80. *Ibid.*, p. 43.

81. *Ibid.*, p. 42.

82. *Ibid.*, p. 43.

83. *Ibid.*, p. 43.

84. Communication from R. J. O'Brien (Regional Manager, Region I, California Department of Fish and Game) to Mr. John Edison on April 28, 1969.

85. The State of California, The Resources Agency, Department of Water Resources. *Bulletin No. 105-3: North Coastal Area Action Program, a Study of the Smith River Basin and Plain.* December, 1970. p. 55.

86. Department of Fish and Game. *Preliminary Report.* p. 29.

87. *Ibid.*, p. 2.

88. *Ibid.*, p. 2.

89. Department of Water Resources. *Bulletin No. 136.* p. 20.

90. Department of Fish and Game. *Fish and Wildlife Problems.* p. 42.

91. The State of California, The Resources Agency, Department of Water Resources. *Bulletin 160-70: Water for California, The California Water Plan Outlook in 1970, Summary Report.* December, 1970. p. 41.

92. Department of Water Resources. *Bulletin No. 136.* p. 87.

93. *Ibid.*, p. 58.

94. *Ibid.*, p. 96.

95. *Ibid.*, p. 140.

96. *Ibid.*, p. 18.

97. Department of Fish and Game. *Fish and Wildlife Problems.* p. 28.

98. *Ibid.*, p. 47.

99. *Ibid.*, p. 19.

100. Department of Water Resources. *Bulletin No. 136.* p. 11.

101. *Ibid.*, p. 11.

102. *Ibid.*, p. 99.

103. Department of Fish and Game. *Fish and Wildlife Problems.* p. 89.

104. Department of Water Resources. *Bulletin No. 136.* p. 134.

105. Department of Fish and Game. *Preliminary Report.* p. 2.

106. *Ibid.*, p. 12.

107. Department of Water Resources. *Bulletin No. 160-70: Summary Report.* p. 6.

108. Department of Fish and Game. *Fish and Wildlife Problems.* p. 94.

109. Department of Water Resources. *Bulletin 160-70.* p. 54.

110. *Ibid.*, p. 16.

Chapter Five

THE SAN FRANCISCO BAY-DELTA: A UNIQUE ESTUARY

I. Definition of An Estuary

Describing an estuary is like explaining the mechanics of the human eye. Each part can be labeled and a function attached, but the real magic is perceived through the actual process of seeing. In the same way, an estuary is important for what it *does* rather than for what it is. Physical-biological phenomena, such as an estuary, are not things, but rather they are *processes* limited in scope by such factors as time and the river flowing.

A standard definition of an estuary is "a semi-enclosed coastal body of water which has a free connection with the open sea and within which seawater is measurably diluted with freshwater derived from land drainage."(1) The most important variable in an estuary is salinity; the gradient of salt concentration will range from almost pure seawater (30 o/oo or parts per thousand) to almost freshwater (5 o/oo). The salt water pumped upstream by tidal forces is denser, or heavier, than the outflowing freshwater; therefore, it lies underneath and creates a "salt wedge." (See Fig. 5-1) The upstream limit of an estuary, often defined as the line where the chloride concentration is 1000 milligrams per liter, is determined by the physical factors that control the movement of the salt wedge; these include wind, tide, and freshwater outflow. The dilution of denser sea water with river water produces density gradients which drive the characteristic estuarine circulation patterns. The primary factor in determining the type of circulation is the role played by tidal effects relative to that of river outflow. Tidal currents provide turbulent mixing between the salt wedge and the overlying freshwater. This minimizes density gradients from surface to bottom.

One of the characteristics of an estuary is its activity as a sediment trap (See Fig. 5-1). Clays, the finest suspended sediments, will remain suspended in freshwater indefinitely. In saltwater, however, these clay particles are flocculated, or clumped, by positive ions and tend to settle to the bottom. As these heavier aggregates settle, they can be resuspended by the turbulence, with the salt wedge carrying them

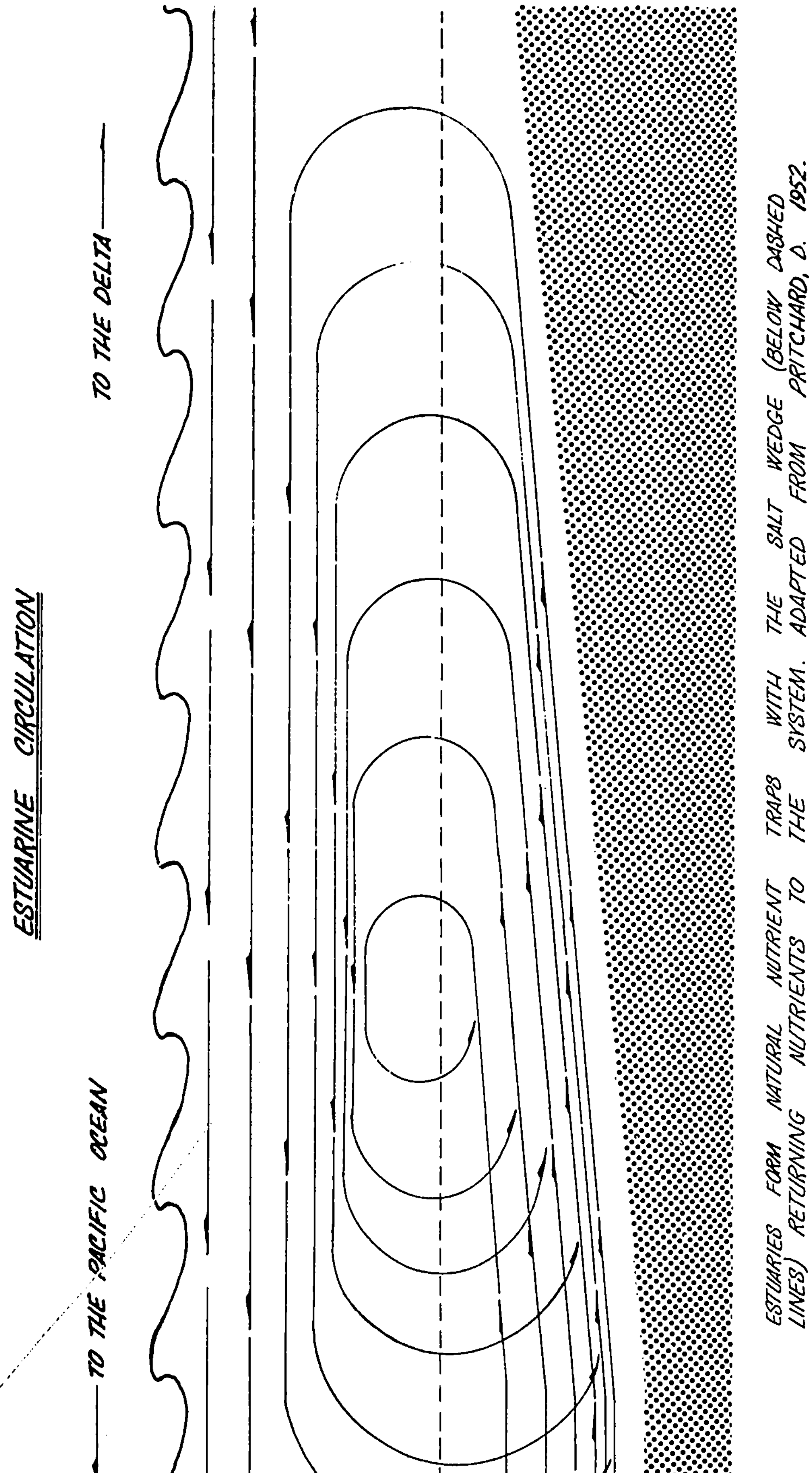

ESTUARINE CIRCULATION
TO THE PACIFIC OCEAN
TO THE DELTA
ESTUARIES FORM NATURAL NUTRIENT TRAPS WITH THE SALT WEDGE (BELOW DASHED LINES) RETURNING NUTRIENTS TO THE SYSTEM. ADAPTED FROM PRITCHARD, D. 1952.

Figure 5-1

upstream. This circulation may occur several times before the sediments flow to the ocean. With this introduction it might be best to explore the physical aspects of an estuary in greater detail.

II. Physical Characteristics

A. Origin of Sediment

Most of the sediment entering an estuarine system is usually supplied by freshwater tributaries. These streams can transport organic and inorganic material in solution, suspension, or traction (bed load). When suspended, the particle's weight is supported by the surrounding fluid. The particle, being heavier than the fluid, tends to settle. If the fluid flow has only horizontal velocity, suspension is only temporary, but if turbulence is present the sediments will be suspended as long as the turbulence remains (2).

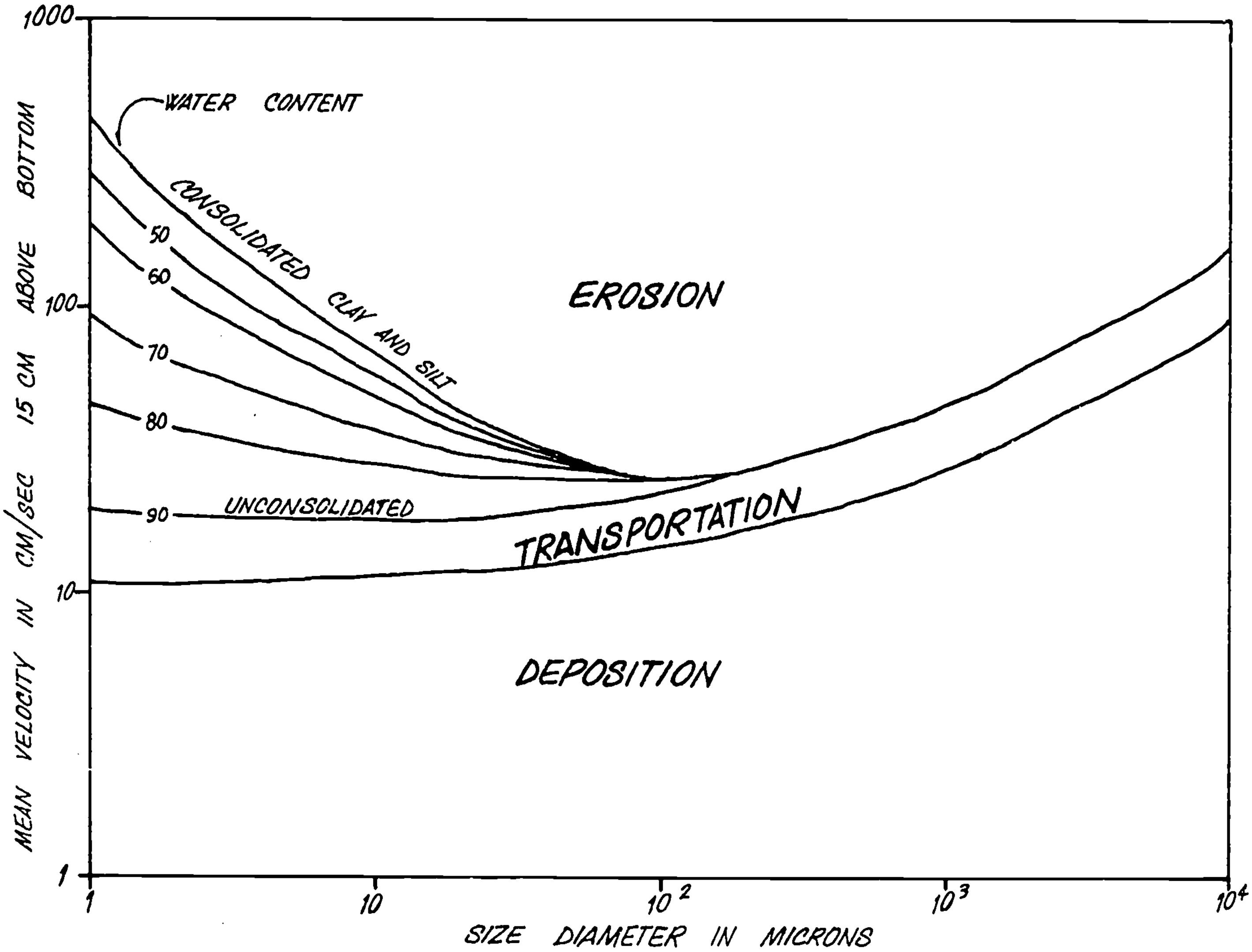
In most streams, the finer part of the sediment load, the *washload* (in suspension), can be transported easily by water and is limited only by its availability in the watershed (3). The coarser part, or *bed load*, is difficult to move by flowing water and is limited in its rate of transport by the ability of the flow to move it. Hence, in any channel with a given bed, the flow will transport the bed load to capacity, while the bed load is a function of the flow rate (4). Flood flows can carry enormous bed loads, while negligible amounts of bed load material may be carried during very low flows.

The predominant bulk of the sediment load in most rivers is in suspension. An analytic relation between suspended load and flow is not practical, since the suspended load is not usually carried to capacity (5). Suspended load theory allows determination of the local sediment distribution, but not of the absolute amount or rate of transport (6).

A general trend of the functional relation between suspended load and flow may be recognizable, from which we can calculate statistical predictions for future rates. The measurement of suspended load for numerous high flows, both during rising and falling stages, possibly during dry and wet years, has been recommended before predicting future sediment loads as a function of river discharge (7).

Relations between the grain size of sediments and erosion and transport velocities have been developed for rivers and coastal areas. The *critical erosion velocity* is the minimum current velocity at which sediment of a particular size begins to move. The movement stops when the flow reaches the lowest transportation velocity or the *deposition velocity*. Critical velocity values depend principally on frictional (or tractive) forces acting on the bottom roughness, turbulence and other factors, and only indirectly on the current velocity.

For particles of diameter greater than 50 microns (sand and coarse silt), both critical erosion velocity and deposition velocity increase with particle size; that is, a larger particle is harder to move and can settle in faster moving water. The velocity difference between erosion and deposition is of great importance for the behavior of suspended matter in tidal streams. For small particles of diameter less than 50 microns (finer silt and clay), their cohesiveness and duration of consolidation become important and the relationships between erosion, depositional velocities, and size become more complex. (See Fig. 5-2)



EROSION, TRANSPORTATION, AND DEPOSITION VELOCITIES FOR DIFFERENT GRAIN SIZES. THE DIAGRAM INDICATES POSSIBLE VALUES FOR VARIOUS STAGES OF CONSOLIDATION. (DATA FROM VARIOUS AUTHORS IN SUNDBORG (1956) AND POSTMA IN LAUFF (1967).)

Figure 5-2

From Figure 5-2 it is clear that the difference between erosion and transportation velocities is much larger for consolidated than for unconsolidated clays or for sands. Recently deposited, very loose and unconsolidated fine grained matter may easily be carried away by quite a small change in current velocity. When the material has been deposited for a longer time, it gradually loses water and becomes increasingly difficult to erode.

The process of consolidation is the result of the expulsion of water from the spaces between particles under pressure. The water escapes through microscopic channels. During the process, the particles form a more dense, closely packed sediment with a lower water content. In sands and most clays these processes are irreversible. Consolidation proceeds very rapidly in sands, but very slowly in silts and clays. The rate of consolidation depends on the type of clay mineral and the degree of flocculation (see below). As the water content decreases, the critical erosion velocity increases and the particle becomes more difficult to erode.

In tidal areas, where the same material is picked up after every slack tide, the particles have little time to consolidate, and the ratio between erosion and transportation velocity will not vary much with grain size. In areas where part of the material is set in motion between longer time intervals, the ratio may increase considerably with decreasing particle size.

B. Estuarine Sediment Transport

Where an estuarine circulation is developed, the concentration of suspended matter often attains values much higher than those in rivers or the sea. The hydrodynamic patterns of estuarine circulation produce this turbidity maximum. As a sediment particle is carried downstream with river water, it may sink into a lower layer which is moving upstream. Vertical mixing may eventually return the particle to the upper water layer where it is moving downstream again. A particle may be transported back and forth several times before it escapes from the estuary to the sea. The stratified estuarine circulation acts as a sediment trap and very high concentrations may be accumulated (Figure 5-1). Water passes freely, but there is a longer residency time for suspended matter.

C. Flocculation

Small particles of colloidal size (less than 0.1 micron) may contain an electric charge which influences their behavior in suspension. The surface ions of clay crystals usually have unsatisfied positive charges which attract negatively charged ions such as hydroxide (OH^-) from the water. Each particle thus adsorbs a shell of negatively charged ions (9). Clay particles have a very large surface area relative to their weight and adsorption can occur readily. Since the particles all have charges of the same polarity, their mutual repulsion keeps them dispersed, making settling difficult. This occurs in freshwater.

Anything that will neutralize or diminish the charge will cause the particles to flocculate, or stick together (1). Sea water contains ample electrolytes – magnesium (Mg^{++} and sodium (Na^+) ions – to initiate this process. The small particles conglomerate to larger units and tend to sink faster than individual clay flakes. It has been observed that polyvalent ions are more effective in coagulating colloids than

univalent ions. The thickness of the adsorbed film depends on the valence of the adsorbed ions, the total ion concentration in the surrounding water, and pH (11).

Thus, clay particles tend to flocculate in sea water. Pollution in many rivers causes flocculation because of polyvalent positive ions in industrial wastes and excessive amounts of particulate organic sewage which acts as a binding substance for fine grained particles. The diameter of a floccule may be vastly larger than that of its components, and it settles more quickly. However, very turbulent flows can disrupt aggregates and the dispersed particles can later re-aggregate. Flocculated particles, organic or inorganic, caught in vertical turbulence will be held in suspension for a long time or until transported into quiet areas where they can settle (12).

It is difficult to evaluate the actual settling velocity of floccules in the field, because their size is regulated not only by salinity differences but also by sediment concentration and flow conditions (13). The problem of deposition of colloidal particles in estuaries is complicated and not entirely resolved.

D. Resuspension and Deposition

As a river enters its delta, the coarse particles settle out as water motion decreases. A large portion of incoming sediment first deposits in the shallow areas of the estuary, a smaller part settles in channels and around docks and the remainder passes to the ocean (14). Breezes produce waves which winnow, or resuspend, sediments deposited in shallow areas. Such resuspended sediments circulate with tidal currents and accumulate in areas where waves and currents do not resuspend them: in channels and around docks. Wave action is predominant in regulating the sedimentation of shallow areas and tidal flats, while current velocities determine deposition in tidal channels (15).

Tidal currents are usually sufficiently strong and turbulent to set in motion considerable amounts of suspended matter. During spring tides, when there is the greatest difference between high and low tide, the strong currents prevailing then will generally bring more material into suspension than will the neap tide currents, when the least tidal difference occurs. Hence, in the neap tide period, part of the material participating in tidal circulation will remain on the bottom for as long as a week or ten days. The material will have time to consolidate and erosion in the next spring tide is at first difficult (16).

In shallow areas subject to tidal and wave action, where the bottom sediment distribution is determined by oscillating water movements, the average grain size increases with decreasing water depth. This effect occurs because the turbulence caused by waves is greater in the shallower water so that the coarser sediment is winnowed from the bottom, suspended and carried elsewhere by currents. If marine sediments have entered the system, they will be mixed with fluvial, or river, sediments and both sorted into well differentiated, homogeneous sediment types that provide no clue to a simple determination of the origin of the deposits.

This sorting of sediment has been observed in San Pablo Bay (17). The sediment texture at the bottom of shallow areas was found to be mostly very fine grained silt and clay during the winter floods when winds are calm and wave action is small. Summer breezes produce waves that winnow the fine

sediments and suspend them for transport to deeper areas where they will not be resuspended. By fall, the bottom sediment is predominantly fine sand, which is more stable than silt and not as easily winnowed by waves.

The complicated water movements in the Bay-Delta transport, sort, and modify the sediment. It is deposited, eroded, and resuspended many times before it finally settles, either permanently or for a long period. The portions that do settle out are deposited mainly in deep, quiet areas, relatively free of waves where the water is at rest at each turn of the tide long enough for settling to occur.

E. Turbidity

Estuarine waters are characteristically turbid (muddy) because of a combination of factors: 1) the presence of particulate matter carried by tributary rivers, scoured from the bottom by tidal currents and waves, loosened by burrowing animals, and resulting from the organic decomposition; and 2) the net two-layered opposing estuarine circulation pattern (See Figure 5-1). These processes compete with mechanisms that tend to cause deposition of sediment: 1) the mixing of fresh and seawater and consequent flocculation of finer particles which contributes to settling; and 2) the existence of relatively quiet settling areas provided by semi-enclosures and deep areas. The amount of suspended matter brought by the tributaries seems to be the most important factor in determining the magnitude of the turbidity maximum, with the strength of the estuarine circulation and the settling velocity of particles exerting strong influences (18).

III. Biological Characteristics of an Estuary

A. Permanence and Change

An estuary is an unstable environment for the organisms living there. Daily changes occur with each tide, while seasonal changes correspond to the amount of fresh water outflow. At first one might expect this instability to result in transient, poorly established populations, but the opposite is actually true. The reason has been explained succinctly by Joel Hedgpeth when he wrote:

> Although the variation of environmental factors may be large, it is nevertheless a permanent feature of the estuarine environment, and thus the organisms which become adapted to the fluctuations in estuaries have found an environment which may actually be comparatively stable in the geological sense, since the range of environmental factors may be greater than the secular change of an environment without such short-term fluctuations. That is, the aggregate rate of change in the estuarine environment may actually be less than in the geographical province in which it occurs over the same period of time (19).

Therefore, the general characteristic of estuarine life forms is not *transience*, but *permanency*. Estuarine organisms are conservative; they have displayed very little change over a great expanse of time. Fossilized remains of organisms such as clams and oysters often look just like their modern descendents. The estuaries of the world show a great monotony of life forms as compared with those of the sea (20).

What requirements are necessary for the success of an estuarine organism? Most importantly, it must be able to cope with the wide salinity range; the ecologically significant aspect of salinity is not the *average*

value but the *range* on a daily and seasonal basis. Organisms that are able to cope with this environmental stress are denoted as euryhaline, as contrasted to stenohaline organisms that tolerate only a narrow range of salinity. Many of the organisms in an estuary, however, are not necessarily strongly euryhaline; rather, they rely on their mobility to stay within their preferred salinity range. Most often these organisms enter and leave the estuary with the tides. Most true estuarine organisms are euryhaline marine forms able to penetrate and exist in this unstable environment (21). Some freshwater forms are also found, especially in the upper portion of the estuary.

B. Characteristics of Estuarine Crustaceans

No organism can excel at everything. In order to remain euryhaline, and partly because they are euryhaline, these organisms remained generalized with regard to their life style. Animals, in general, exhibit a whole range of specialization, from the everglades kite, a hawk-like bird that feeds only on one species of snail, to such cosmopolitan organisms as the starling, the Norway rat, and man. Many estuarine organisms exhibit generalized feeding habits. Mysids, a characteristic estuarine shrimplike crustacean, are able to filter from the water diatoms and finely divided organic particles, but they also can capture smaller animals, such as other crustaceans. Finally, they will scavenge on larger dead organisms. This wide range of feeding, together with their medium size, make them important links in the estuarine food web, where they utilize various types of material and provide food for a variety of fish (22).

C. Fish In the Estuarine System

Fish are an important part of the estuarine ecosystem. Of primary importance are the anadromous fish, those that spawn in freshwater and mature in the ocean. The salmon is a familiar example. The estuary provides a gradual transition zone between the ocean habitat and the spawning ground far upstream; the environmental shock of suddenly switching from salt to freshwater would present serious problems to these fish.

Estuaries are also nurseries for many species of fish. The waters of an estuary are characteristically turbid, nutrient-rich, and full of food for fish. These factors provide an ideal place for a fingerling to grow and hide from predators.

D. The Food Web

1. Light, Nutrients, and Plants

The food web of an estuary is complex and highly productive. In fact, the salt marshes that border the water capture 5 to 10 times as much energy from the sun per acre as a highly cultivated wheat field in North America (23). A large percentage of this plant material is converted to detritus (partially decomposed organic material) before it is utilized by animals (24). While the main source of detritus is from the larger rooted plants, the floating, unicellular plants, or phytoplankton, must not be neglected. Nutrients, like

simple compounds of nitrogen and phosphorus, are caught and circulated in an estuary in the same manner as are suspended sediments. These nutrients, plus sunlight, are taken up by the phytoplankton. Because of the high turbidity of the water, only the top layer of the water may receive enough light to permit photosynthesis. The depth at which the light intensity is reduced to 1% of the surface light is usually considered to be the extent of the water column where photosynthesis is important. This layer of water is defined as the *euphotic zone*. There is a complex mathematical relationship between surface light intensity, the light intensity at a certain depth, and the concentration and nature of the suspended particles.

2. Animals Forming the Food Web

The phytoplankton and detritus provide an ideal food source for zooplankton, the small animals that float in the water. The concentration of plankton at a salinity range of 7-10 0/000 may be several times as great as found in the ocean (25). This high concentration of biomass is used as a food source for the resident and migratory fish in an estuary. Also, material reaching the bottom will be utilized by beds of clams, mussels, and oysters.

The waters, mud flats, and marshes of an estuary also may be a very important habitat for many birds. In fact, the major flyways of the world utilize many estuaries for feeding, resting, and nesting (26).

An estuary is characterized by high turbidity, nutrient concentration, and organic productivity and has a complex food web. The ecological balance is maintained because of, not despite, daily and seasonal variation of physical factors. The biological character of an estuary is easily modified or even destroyed (27). This is a very real problem, because most estuaries, especially in this country, are surrounded by heavy concentrations of people. Man has become the most important biological aspect of estuaries.

IV. The San Francisco Bay-Delta Estuary

The Bay-Delta estuary is a unique system. Much of the precipitation falling on the Sierra Nevada drains through the Bay-Delta system. 50,000 square miles, 40% of the entire land area of the state, drains into the Bay. Nearly all of this land, 46,500 square miles, is located in the Central Valley, which is drained by the Sacramento River in the north and the San Joaquin River south of the Bay Area (28). These two rivers, and smaller streams like the Mokelumne, meet and form the Delta (See Figure 3-3). The Delta, bordered by the Sacramento River on the north and the San Joaquin on the south is a roughly triangular area 738,000 acres in extent, laced with over 700 miles of waterways. The low profile of the highly productive land stands in sharp contrast to the coastal foothills. The water flows into the estuarine portion of the San Francisco Bay-Delta system, the largest river mouth in California. Suisun Bay, located just west of the confluence of the Sacramento and San Joaquin Rivers, is connected to San Pablo Bay by the narrow Carquinez Strait. These form the major portion of the estuary.The shallow water, an average of less than 20 feet, is a mixture of the fresh Delta outflow and the sea water pumped in by the tides. The fresh water, now commingled with the sea, continues its trek westward into the San Francisco Bay. Here also estuarine characteristics can also be recognized; none of the Bay has a salinity equal to sea water.

If the Bay-Delta system was a typical estuary, the freshwater would continue to flow into the ocean. To a large extent it does, but water movement is greatly complicated by the lower arm of this system, the South Bay. The South Bay is a "negative estuary"; it does not have any substantial freshwater upstream source, but the sea water is measurably diluted by Delta outflow. There is good evidence showing that seasonal salinity variation in the South Bay is largely controlled by freshwater outflow from the Delta (29). Most of the flushing action in the South Bay is a result of this freshwater outflow especially during the winter months; tidal action causes mixing of the waters and may provide some additional circulation (30). This flushing from Delta waters is especially important because there is no other significant freshwater source discharging into it.

The Pacific Ocean, the western boundary, is connected to the Bay-Delta system through the narrow opening of the Golden Gate. The dividing line between ocean and estuary is by nature fluctuating, depending on freshwater outflow and tidal cycle.

A. Freshwater Flow Into the Bay-Delta

The salinity distribution depends upon movement and mixing which are functions of wind, tide, and inflow of the rivers. Of primary interest here are the sources of freshwater flow into the Delta: the Sacramento River, the San Joaquin River, several minor eastern streams from the Sierra Nevada, precipitation within the Delta, and storm runoff (31). Exportation demands have reduced the total flow of water. At present, the annual outflow is 53% of the historic flow before diversion and could be an estimated 19% in 1990 and 8% in 2020 because of added demands on exportation (32). There is also a seasonal variation in fresh water flow; at present, it peaks from January to March and reaches its low from June through September (33).

The combined discharge of the Sacramento and San Joaquin Rivers, when in flood, can flush out Suisun Bay and freshen San Pablo Bay (35). At present, adequate flushing for salinity intrusion and elimination of waste discharges occurs just about every year. It has been predicted that by the year 2020, with reduced Delta outflow, the necessary freshwater flushing will occur in only one out of every three years (36). The concentration of waste discharge throughout the year is strongly influenced by the degree of flushing of the estuary which occurs in the winter time (37).

There is an infinite range of hydraulic conditions within the Delta based on the quantity of fresh water inflow, export demands, and variations of hydrologic balance. Average individual channel hydraulics vary seasonally and depend on the demands of the state and federal pumping facilities near Tracy, at the southern end of the Delta, and on the Sacramento River outflows. Generally, uniform tidal velocities between winter and summer flow conditions are maintained in the Delta; net velocities in individual channels are a function of the pumping for the federally-operated Delta-Mendota Canal, which begins at the southern tip of the Delta (38).

Table 5-1

Average Monthly Delta Inflows (1955-64)
measured in cubic feet per second (cfs)

Month	Sacramento River	San Joaquin River
Jan.	25,140	4,510
Feb.	38,600	4,730
March	33,740	3,710
April	28,830	4,930
May	26,690	5,500
June	16,040	4,490
July	10,970	1,020
Aug	11,230	650
Sept	12,140	990
Oct	12,820	1,340
Nov	13,610	1,580
Dec	23,390	2,870
Average	21,100	3,025
Range	10,970–38,600	650–5,500

B. Physical Factors

Shallow, well-mixed, oxygenated, tidal areas play a very important role in maintaining healthy dissolved oxygen (DO) levels in adjacent deeper areas of the Bay-Delta Estuary. In the Antioch region the dissolved oxygen concentrations are lower since there are limited areas from which oxygenated shallow waters can mix with deep channel waters (39).

Temperature can modify the effects of salinity and change the salinity range within which an organism can survive: likewise, salinity can influence the effects of temperature (40). Temperature is also an important factor for migration and spawning of fishes, irrigation of agricultural land, and waste assimilation. Temperature in the Bay-Delta region has been relatively stable over the past 10 to 15 years. Seasonal variations (44°F. in December through January to 78°F. in July to September) are caused by seasonal changes in atmospheric temperature, sunlight intensity, turbidity, and agricultural drainage (41). In this large body of water temperature varies horizontally, (i.e., from the shore out to the center), and vertically, (i.e., from the surface to the bottom) (42).

Estuarine waters are usually alkaline. Variations in pH are a function of both temperature and salinity. Biological activity causes the pH values to be the highest during daylight hours (respiration involves the uptake of carbon dioxide, which decreases the acidity) (43).

C. Limiting Factors

The quality and quantity of the nutrients available in an estuary also determine which life systems can be supported. In order for biostimulation to occur, certain prerequisites for activity must be available in the necessary amounts. Those factors not present in high enough concentrations for activity to occur are called *limiting factors*. When these factors increase in availability, the organisms respond sensitively and will soon increase in number. Of particular importance are the limiting factors affecting algae growth.

One factor, euphotic zone as regulated by turbidity level, has already been mentioned. Another is nitrogen (N), an important nutrient. The most significant source of nitrogen-containing nutrients in streams is fertilizer; cotton and vegetable crops in the Central Valley are heavily fertilized (44). Soil type, fertilizer application, rainfall, and irrigation practice vary the N loads from agricultural runoff. The effluents from domestic wastes discharged are another primary source of N in river and Bay waters (45).

N is present in various chemical forms, both organic (e.g., protein) and inorganic (e.g., ammonia) forms. Waste materials usually contain ammonia (NH_3) which bacteria oxidize to nitrite (NO_2). Other bacteria may further oxidize NO_2 to nitrate (NO_3). During algal growth, such inorganic forms of N are utilized and converted to organic forms. Other organisms, such as zooplankton and bacteria, also convert inorganic N to organic forms. The N cycle follows seasonal patterns; during times of low algae activity most of the total N is present in NO_3; during high algae activity (May-October) organic forms of N are dominant (46).

N concentration in the Bay region ranges from less than 1 mg/l to 3 mg/l. The highest concentration is found in the South Bay near San Jose due to the sewage from Coyote Creek, which carries sewage from South Bay cities. Suisun Bay is the area of next highest concentration with 1-2 mg/l (47).

The controversy around N centers on whether it is a limiting factor for algae growth. Many people trained in water quality feel that it is limiting (48, 49, 50), although there is not complete agreement on this point (51). Experiments by the Federal Water Pollution Control Administration (FWPCA – now the Water Quality Office of the EPA) have shown that an increase in inorganic N stimulates growth of resident Bay-Delta planktonic algae. The agency has established a maximum safe concentration of N at 2.0 mg/1. Algae blooms could result if the concentration is higher.

The United States Bureau of Reclamation (USBR) prefers to rely on a study by the Kaiser Engineers for the support that N is not limiting (52). In this report, three studies on N concentration in the Bay were conducted. The first one was a field sample conducted at two stations over four days in March of 1968. They found that N was not limiting. However, their findings may be disputed in light of the fact that at that time of year with high water flows, short nutrient residence time, high turbidity, cool water temperature, and low light intensity, it is unlikely that there could have been algae growth to consume the N.

A second study was an enrichment test using the diatom *Navicula*, a microscopic algae whose walls contain silica. The algae were placed in test tubes with water from different parts of the Bay, and different concentrations of N as $NaNO_3$ were added. The authors were unable to find out the time of year when the water samples were taken, and it is known that seasonal changes within the Bay affect algal growth. The

report stated "The responses of *Navicula* . . . are difficult to interpret because of the differences among Bay waters." From the graphs included in the report, it appeared that N stimulated algae growth in the North, San Pablo, and Suisun Bays. This finding would seem to indicate that N *was* limiting for algae in these areas.

The final study on N mass balance showed that for 1962, inorganic N (nitrates) was in excess of organic N (algae) throughout the whole year and was therefore not limiting (53). In toto, the Kaiser study is inconsistent and inconclusive in its determination of N as a limiting factor.

Phosphorus (P) is contributed by sewage (significantly from detergents) and by the outflow from Delta agricultural lands (peat soil is high in P). Concentrations are fairly uniform throughout the Bay-Delta system and range from 0.10 to 0.30 mg/l. P is constantly recycled into the waters from suspended and bottom sediments; turbulence therefore increases the amount of P in the water. This nutrient is not considered a limiting factor (54).

Carbon dioxide (CO_2) is removed from the water by various organisms and used as a carbon source for photosynthesis. In sea water, CO_2 exists as bicarbonate and carbonate ions. The Bay-Delta waters do not lack bicarbonate and carbonate ions; therefore, carbon is not considered a limiting factor for algae growth (55).

Dissolved silica (Si) comes into the Bay from freshwater flows which have drained from the land. The concentration is seasonal with the highest (20 mg/1) occurring during high runoff periods. During the summer, however, the level may drop to less than 1 mg/1 and may become limiting for diatoms, an important group of phytoplanktons which use Si for shell formation. With possible decreased sediment flow into the Delta due to freshwater diversions, Si may become limiting all year around (56).

Vitamins are another nutrient group that is being studied because it may be a limiting factor. Of concern are vitamin B_{12} thiamine, and biotine – because, while their functions are unclear, they are essential for some algae populations (57, 58).

Although not a nutrient, pesticides may be considered "additives" to the water. Pesticides occur in the aquatic life of the Bay-Delta region in higher concentrations than are found in surrounding waters (59). One study of 145 pesticides from 1963 through 1964 showed that pesticide concentrations ranged from 2.70 parts per billion (ppb) to 0.02 ppb. The average maximum total chlorinated hydrocarbon level (MCH_t) was 0.18 ppb. The MCH_t concentration was about 70% higher in the San Joaquin River. Besides regional differences, there are seasonal variations; the summer values were 2.5 to 4.0 times greater than the winter values (60).

Because of their adsorptive properties, sediments contain many times the concentration of pesticides than the surrounding waters; the average value being 220 ppb. The pesticide concentration was somewhat related to sediment particle size because smaller particles have more adsorptive area per unit volume. The higher concentration was found in muds and organic materials while the lower concentration was associated with larger grain size and inorganic materials (61).

All the properties here discussed are related to a concept about which little has been written: residence time. The effect of salinity, circulation, sedimentation, and nutrients on water quality depends

on the time the factors are operating within the estuary. The lethal effect of a toxic component of the environment is partly dependent on the duration of exposure; i.e., its residence time (62). Residence time of organisms also affects their growth; organisms need time to assimilate the nutrients and sunlight.

Estuaries are zones of reduced competition where physical factors rather than biotic ones determine the population dynamics. Organisms within an estuary must be able to withstand extreme conditions and fluctuations of the environment. The organisms must have mechanisms for protection, tolerance, acclimation, and regulation (63). The study of life forms within the estuary involves the investigation of numerous, inter-related systems and properties, most of which are incompletely understood.

The organisms within an estuary are of several different types. There are the benthic organisms which live close to or on a substrate. The neritic type spend most of the time afloat but during unfavorable conditions rest on the bottom of the estuary. Plankton, which will be of primary concern for this paper, spend all of the time floating (64).

D. Biological Components

1. Algal Growth In the Bay-Delta

A detailed description of the life cycle of phytoplankton is essential when trying to understand the effects of reduced Delta outflow and the addition of nutrients on water quality. Growth models are usually based on the conservation of masses; mass theory transformation is better understood than corresponding energy transfer from species to species. The population is characterized as a whole by a measurement of the biomass of the phytoplankton present. The primary dependent variables of such models are phytoplankton, zooplankton, and nutrient concentration. Temperature, flow, and solar radiation influence the system (65).

The optimum temperature for algae growth is between 20° and $25^{\circ}C$. If there is a large advective flow (unidirectional flow like the fresh water flow in an estuary), it will wash out an algae population within a region and therefore net population growth will be less (66).

The light intensity to which phytoplankton is exposed does not remain uniform nor at the optimum value for growth. The intensity varies with the time of day and depth of the water (turbidity is different at different depths). When the nutrient concentration reaches a sufficient level, algae growth then proceeds at a rate determined by the light and temperature conditions present. Conversely, the algae growth rate becomes linearly proportional to the substrate concentration when the concentration is low (67).

During the daylight period, the algae contribute to the increase in dissolved oxygen (DO) levels in the water through their photosynthesis. However, at night while the algae are only respiring, DO levels decline markedly.

Algae can grow to such high concentrations that the water becomes turbid; this is an organic turbidity which has different properties from inorganic turbidity caused by sediment inflow. Light then becomes limiting; this phenomena is called "self-shading." When the algae "bloom" is no longer able to capture sunlight, it starts to die (68). Algae death is also caused by sinking and by zooplankton grazing. Since cells

are heavier than water, they still have a net downward velocity and will sink out of the Euphotic zone. However, in a shallow, well-mixed estuary, this effect is not very significant (69).

The oxidative decomposition and rise in bacterial levels that occurs with self-shading impose the dangerous drop in DO levels. Eutrophication is the name given to the process of blooming and decaying. Characteristics of eutrophication are H_2S formation (which has a rotten egg smell and is toxic at low concentrations and blackens lead base paints) and most importantly, DO increases (70).

From mid-autumn to mid-winter, algae growth is at a minimum because of winter turbulence, reduced light intensity, and increased freshwater flows. During this time, nutrient quantities rise to a high level (71). With the increase in light and water temperature in the spring and summer, biostimulation begins (72).

Under conditions unaffected by pollution, the population for each algae species is low and the number of different species is high. With pollution, the diversity goes down, and there is an increase in population among a few species. The distribution of biomass of algae into fewer species decreases its usefulness of food within the estuarine food web (73).

At present, in the Bay-Delta system, the dominant flora are the centric diatoms which include the genera *Skeletonema, Thallasiosira, Coscinodiscus, Melosira,* and *Cyclotella*. The next most abundant group are the pennate diatoms *Nitzschia, Navicula*, and *Pleurosigma*. Dinoflagellates prefer the more marine (i.e., salty) areas of the Bay-Delta. In general, their population is low with *Ceratium* and *Peridinium* being the predominant genera. The discoloration of the Bay that occurred in 1966 may have been caused by the red-pigmented marine ciliate *Mesodinium*. The phytoblue-green algae have less tolerance to high salinity, and the nuisance-causing genera are normally found in the fresh water portions of an estuary. The predominant green seaweeds found in the Bay are the *Ulva, Chaetomorpha*, and *Enteromorpha* genera. Mats of these green seaweeds were decomposing and reaching nuisance proportions in July of 1966, at the Albany tide flat area in the vicinity of a sewage treatment plant outfall (74).

It should be noted that as of 1970, a statement made by Di Toro, *et al.* who had just finished a very detailed model on phytoplankton growth reported that a "complete investigation of the environmental influences on the growth rate is still to be made" and that "these effects are different for differing species." (75)

2. Decomposition and Bacterial Activity

The base of the food web within the estuary is detritus. Detritus is the "biogenic material in various stages of microbial decomposition which represents potential energy sources for consumer species." (76) There are three agents of decomposition: Autolysis (self-decomposition), digestive secretions, and chemical activity of bacteria and fungi. There is a chemical simplification by hydrolysis and oxidation. Plant detritus tends to persist the longest because it contains cellulose, lignins and biopigments, which resist decomposition. Detritus creates some nuisance factors. Oxidation of the material causes the decreased DO. Colloidal detritus will adhere to exposed surfaces and form larger dispersed particles like oozes, slimes on surfaces of

small objects, and sludges on muddy floors (77).

Bacteria and fungi are the primary agents in the decomposition of organic material (78). Bacteriological quality is measured by the presence of coliform bacteria (Escherichia coli, an ubiquitous human gut inhabitant). While they are not dangerous to human health per se, coliforms are used as indicators for the presence of other pathogenic organisms. (See Joseph Welsh, et al, *The Politics of Pollution Control in Monterey Bay*.) A population of coliform bacteria resulting in the most probable number (MPN) of 1,000 colonies/100 ml or less when cultured in the laboratory, is the maximum allowed in areas of water contact sports (79). Generally, there is a high concentration found in the western Delta with decreased concentrations out through the Bay (local exceptions near waste dischargers). Most of Suisun Bay and San Pablo Bay and localized areas of San Francisco Bay presently exceed 1,000 colonies/100 ml over 20% of the time. Bacteria adhere to detrital material, some of which settles to the bottom and is used as a source of food for filter feeders. At present, harvesting of shellfish from Bay waters is not permitted for human consumption because of such high bacteria counts (80).

Shellfish Bay supports clam and oyster beds. Oysters, and bivalves in general, were a major food source for natives in the San Francisco Bay Area for several thousand years. Now these ancient food sources are being threatened. Both native oysters and the commercially important Eastern oysters transplanted during the last century thrive in an estuarine habitat. While they cannot survive in pure fresh water, the flushing action helps rid them of damaging parasites and eliminates species that compete with the oyster for food. At present, the shellfish industry is on the decline. Dense strands of mussels that represent a potential resource for protein supplement or livestock food cannot be eaten because of the sanitation problem previously mentioned. Crab populations are seriously declining, too, and this fact has been associated with concentrations of DDT (81). Reduced DO levels cause asphyxiation of clams and snails (82). It has been reported that suspended and settleable sediments and organic pollution have been the primary factors in the decrease of the fishery (83).

3. Marine Foulers

Fouling organisms and marine borers are estuarine organisms that cause problems. Salinity intrusion caused by a reduced freshwater flow brings with it barnacles, algae scums, tunicates, and mussels because these organisms thrive in more saline water. Nutrient enrichment also favors fouling organisms such as algae scums and barnacles. These attach themselves to boat hulls, wharves, and channel buoys and must be removed to prevent damage. Pleasure boats kept in Bay marinas usually have their hulls cleaned every nine to twelve months; boats in enriched areas require hull maintenance every six to eight months. A survey made on twelve boat maintenance yards concluded that boring and/or fouling organisms with their resultant problems were increasing in San Francisco Bay (84).

4. The Bay-Delta Fisheries

The Bay-Delta region is an important spawning and nursery area for anadromous fishes (e.g., salmon)

and it supports more than 150 other species of fish. Most important of the fishes are the jacksmelt, perch, herring, anchovies, sole, tom cod, flounder, channel and white-catfish, black bass, crappie, and sunfish. Important anadromous fishes are the king salmon, striped bass, American shad, steelhead, and sturgeon (85).

The king salmon population in this area numbers about one million (86). The fish spawns in fresh waters with temperatures ranging from 40° to 56°F. (87). The female buries her fertilized eggs in the gravel-bottomed upper reaches of the Sacramento River system, they develop and hatch 50 to 60 days later, and the young swim to the sea to mature. Three to five years later they return to the same area in which they were born in order to spawn and die. There are three races of salmon each with a different spawning time, "fall," "winter," and "spring" runs. The fall is the biggest and most important (88).

The striped bass population is much larger with 2.5 to 8 million individuals (89). The adults spawn during the spring in the fresh waters of the Delta. They spend the rest of the year in the Suisun, San Pablo, and San Francisco Bays. The eggs are carried by the currents and depend on the moving water to provide an oxygen source and carry away the carbon dioxide. Hatching depends on the water temperature (90). The young bass use the Delta and Suisun areas for nursery grounds (91). With increasing age, the bass move downstream to join the adult population (92).

Toxic waste dischargers have caused fish kills. During late spring and early summer for the past years, large numbers of striped bass and other fishes have died. *No similar mortalities seem to occur in other estuaries around the country* (93). Ship channels cause deep trenches, and low DO levels occur more easily. A ship channel near Stockton has had low enough DO concentrations to result in one or more fish kills almost every summer (94).

The primary food source for the juvenile fishes in the estuary is the benthic mysid crustacean, *Neomysis* (opposum shrimp). Large populations capable of supporting young fish are found mostly in Suisun Bay and the western Delta; they move back and forth with the salinity gradient. They prefer deeper channels because they do not tolerate high light intensity. It seems that their upstream range is restricted by current velocity, light intensity, and dissolved oxygen. Neomysis cannot tolerate greater than 72°F., and this is nearly exceeded at present in late summer and early fall (95).

5. Bird Life in the Bay-Delta

The Bay-Delta region, especially Suisun Marsh, supports over 100 species of waterfowl and shore birds. This area, used as a feeding ground, sheltered resting place, and limited nesting site, is part of the Pacific Flyway. There are five refuges or waterfowl management areas in the region (96). The waterfowl population numbers 200,000 to 1,000,000; shorebirds, 100,000 to 900,000 (97). The overall abundance of the shorebirds seems less than the waterfowl, but they are more widely distributed. Studies indicate a decrease in population of certain types of shorebirds in the last two to three decades, but the cause is unknown (98).

It is evident from the past discussion of the physical and biological characteristics of the San Fran-

cisco Bay-Delta Estuary that we are dealing with an extremely complex system. However, we have not yet discussed a factor that becomes more important with every passing dawn: mankind. Man is now the most important factor in the Bay-Delta system. Before moving into what man may accomplish with the implementation of the California Water Plan, we will outline what man has done in the past. Thus historical change may give insight into future change.

E. Historical Changes in the Bay-Delta System

In order to discuss changes rendered on the estuary, it is necessary to describe the baseline or natural conditions. Using the term "natural" may have contestible connotations; it is used here to describe those conditions before significant development that occurred after the coming of western man.

The population structure of the precolonial cultures in the Bay-Delta system was remarkable both for its number and diversity. At the time of Spanish settlement in the late 18th century, at least 8 tribes occupied the San Francisco Bay region. The earliest remains of which there is a record in the Bay Area date back 5,000 years (99).

Land and water use by the prehistoric Indians was, by our standards, very light. The major source of food was the Bay, providing fish, shellfish, and a whole variety of plant material. Also, waterfowl and wild game such as deer and elk were utilized. Some minerals were mined, such as obsidian, flint, soapstone, and cinnabar. Not all materials were local to the area, and could only be acquired through barter with other tribes.

These cultures did leave their mark on the Bay Area, especially those living near the water. Because they placed such a heavy dependence on shellfish for food, large accumulations of mussel and clam shells formed. In 1908, 425 shell mounds were surveyed by the University of California. In 1969, another survey listed 2,080 archeological sites in the Bay Area, attesting to human occupation for a long time (100).

The surface area of the Bay, under natural conditions, was about 680 square miles. The Bay, however, is quite shallow, with an average of only about 20 feet. Much of the perimeter, made up of tidal flats and salt marshes, was periodically exposed and flooded by the tides. In 1850 there were 300 square miles of marshes.

Freshwater outflow showed great seasonal variations. The estimated low flow was probably about 1500 cubic feet per second (cfs), while during the wet season there was as much as 40,000 to 50,000 cfs Delta outflow. Therefore the Bay-Delta system was subject to a wide range of conditions.

The Bay-Delta system displayed a wealth of organisms, including many species of water and shorebirds, fish, and invertebrates. These organisms were adapted to the fluctuating conditions of the estuary.

Development by Western man led to the most rapid changes experienced in the history of the Bay-Delta system. While there is no data available before 1850, it was evident that the Gold Rush brought about profound changes. Hydraulic mining, farming, logging, overgrazing, and roadbuilding contributed to a rapid buildup of sediment flowing into the Bay (101).

In 1850, most of the Bay was owned by the federal government and the newly formed state of

California. By 1909, however, substantial chunks were sold to private parties. This brought about great changes in the Bay later in the century.

Before the 1920's, fresh water extended to the Carquinez Straits, but over . years the reduced fresh water flow due to upstream diversion for agricultural development in the Central Valley has increased salinity intrusion (102, 103). With construction of the Shasta, Friant, Folsom, and Oroville Dams on the Sacramento, San Joaquin, and Feather Rivers, respectively, salinity intrusion and extreme variation have been controlled by releases from these dams. In no year since completion of the Shasta Dam (1944) has there been severe intrusion into the interior of the Delta as there was in the 1920's and 30's, when saltwater would reach as far as Stockton (104). However, in 1957, the USBR curtailed the freshwater releases from Shasta. Under pressure from Contra Costa County, curtailment was rescinded, but at that time the Bureau stated that it was not responsible for keeping seawater out of the Delta (105). In 1971, however, the State Water Resources Control Board stated that salinity control in the Delta is a purpose of the Bureau's Central Valley Project (106).

Water development has occurred on such a scale in recent years that this paper can only briefly outline the big changes. Under the conceptual framework of the California Water Plan, a bond issue was proposed by the state legislature in order to finance the State Water Project (SWP). The bond for $1.75 billion passed by a slim margin in a general election in November, 1960. The basic idea behind the project was to move northern "surplus" waters south where farms and population centers created a large demand. The Oroville Dam on the Feather River would store this water, then it would be drawn through the Delta to the California Aqueduct, where pumps send the water south. The SWP contained provisions for a cross-Delta facility; the one now proposed is the Peripheral Canal.

V. Present and Proposed Water Development Projects

A. The Peripheral Canal

This is a proposed joint project between the USBR and the California Department of Water Resources (CDWR). At present, water is pumped from Tracy at the southern end of the Delta for irrigation of the San Joaquin Valley and for Southern California use, but the quality of the water is lowered as it moves from the Sacramento River through the Delta. The function of the Peripheral Canal is to take water from the Sacramento River near Hood to the state and federal export pumps at Tracy so that a firm supply of high quality water can be shipped south. The right of way requires some 5,200 acres of primarily agricultural land. An additional 1,500 acres will be required for outdoor recreational purposes (107).

The Peripheral Canal controversy centers around the reduction of fresh water inflow to the Delta by transporting it around to Tracy via the canal. At the moment, the Sacramento River provides 70% of this Delta inflow; 80% of the total Sacramento River flow could be exported via the Peripheral Canal (108), which will have a flow capacity of 21,800 cfs. Opposition has arisen due to fears that water quality in the Delta will suffer from such a reduction. State authorities hope to control this effect by providing flow

releases at 11 points along the 43-mile Peripheral Canal. Through these release points water would be released from the Peripheral Canal into the Delta. The eastern Delta will benefit from the canal even if there is a high export rate, because the releases will supply a flushing action not now present there.

One other structure will have direct effects on Delta water quality.

B. The San Luis Drain

Salts remain in agricultural soil after evapotranspiration occurs. To assure the continued agricultural production, water must be applied to wash the salts out of the root system. The resulting leachate passes through a tile drainage system and is then collected; what to do with this waste water presents a problem. The proposed solution is to build the San Luis Drain, which is designed to collect agricultural waste water from certain areas of the San Joaquin Valley and transport it to the Delta. The Drain will be a concrete lined canal extending 188 miles northward from Kettleman City to the western edge of the Delta near Antioch (109). Although the final decision to discharge this waste water at Antioch has not been publicly announced, this report will assume that the discharge will occur, because at present it seems the most likely alternative (110). At least three alternatives do exist: to transport the water to Monterey Bay; to allow the waste water to evaporate; or to desalinate the water. About two-thirds of the way from Kettleman to Antioch, near Gustine, a regulating reservoir, the Kesterson Reservoir, will be constructed. The drain capacity will initially be 100 cfs at the southern origin and will increase to 300 cfs at the entrance of Kesterson; from Kesterson to Antioch the flow will be a uniform 450 cfs (111). Throughout its entire length, the Drain will be hydraulically isolated from all surface and ground water, and will carry only subsurface agricultural waste water (112).

At present, the San Luis Drain is a federal (USBR) project and is expected to be completed by 1977. Formerly, it was a joint state (CDWR) and federal (USBR) project, and was known as the San Joaquin Master Drain. However, in 1968, the State withdrew its participation in the project because of the lack of people in the San Joaquin Valley who would commit themselves to purchasing the drainage service (113).

C. The Central Valley Project

The Central Valley Project (CVP) of the Federal Bureau of Reclamation is the other major aspect of the California Water Plan. It has grown to tremendous proportions. Taken over from the state in the 1930's for financial reasons, the Bureau had completed the Shasta Dam by 1944. Additional dams since then have included the Folsom Dam on the American River and the Clair Engle Dam on the Trinity River. The primary objective of the CVP was to supply water to the San Joaquin Valley. The Sacramento River has been used as the major conveyance channel to transport northern waters; the water is then transported across the Delta and pumped into the Delta-Mendota Canal. The state and federal pumping facilities are both located near Tracy at the southern end of the Delta.

The major overall effect of these projects has been to decrease the amount of freshwater flowing through the Bay-Delta system. Before extensive development, Delta outflow averaged 30 million acre-feet

per year (MAF/yr.). This has been reduced to the present level of 18 MAF/yr.). (114). Moreover, the flow has been stabilized; that is, the range of salinity in the stuary is smaller now.

While a great deal of water is being exported from the Bay-Delta system, there are also significant imports. The Hetch-Hetchy and Mokelumne Aqueducts have made possible the concentrated urban developments on the San Francisco Peninsula and in the East Bay area. Currently about 4 million people live in the Bay Area.

This great concentration of people has resulted in a squeeze for suitable land; the result has been that a substantial part of the estuary has been filled in by cities and also by private owners of parts of the Bay. The surface area of the Bay has been reduced by 35%. Much of this reduction has occurred from fill of the marshes; there are only about 60 square miles of marsh left of the 300 square miles present in 1850 (115). Tidal flats have also been reduced in size. There are less than 400 square miles of open water left, and 250 square miles of this is susceptible to fill because of its shallowness. A great deal of the South Bay has been diked off for salt production (116). This overall reduction in surface area of the Bay is a serious problem because it reduces oxygenation of the waters through surface reaeration. Also, the loss of the highly productive marshes results in the loss of all the organisms dependent on the marsh for food and protection.

Compounding the problems even more is pollution in the Bay. About 800 million gallons of domestic sewage and industrial wastes are dumped each day into the Bay. The dischargers currently rely on dilution to render the wastes harmless; the dilution power of the Bay has been reduced with the reduction of freshwater flow and Bay fill.

VI. Water Quality

At present, deterioration of water quality and biological systems is occurring in the Delta. The exportation of water by the USBR and State pumping plants at Tracy is creating damage in two ways: the rapid movement of water across the Delta to the pumps is decreasing the residence time of the water; and reverse flows are occurring which confuse downstream and upstream migration of anadromous fish (117).

The Tracy and State pumping plants have a 15,000 cfs pumping capacity. Water diversion at the Tracy pumps creates an estimated 15 to 30% loss of total bass eggs produced in the estuary. The degree of losses should be greater when the State pumps are in operation. The pumps are equipped with screens that prevent striped bass from entering the canals if they are larger than the larval stage. Present downstream migration of salmon is forced over towards the plants because of water flows. Predictions estimate that 33.5% of the salmon are lost into canals (118).

Decreased survival also occurs with the reduction of food available and increased predation resulting from changes in migration patterns. The pumping is also reducing the opposum shrimp population. The cause for this is unknown, and it is suggested that decreased residence time is a factor (119).

This deterioration of conditions now occurring in the Delta as increasing amounts of fresh water are diverted is used to justify the construction of a peripheral canal. The water development agencies and the California State Department of Fish and Game (DFG) claim that the canal will minimize damage to the

Delta fisheries as the water exports increase (120). It must be pointed out, however, that the amount of water that can be exported is limited without such a Delta facility; as pumping is increased, saline water will reach the pumps and the quality of exported water will fall below standards acceptable to the users in Southern California.

Department of Fish and Game screens used at the Peripheral Canal (if the standard louvre type is used) will lose 20 to 24% of downward salmon migration (this *could* be reduced by using more efficient screens and curtailing pumping during peak migration)(121). However, it is felt that damage post-Peripheral Canal is not irreversible and that the damage that is occurring now is worse and will continue to increase (122).

The State Water Resources Control Board, a quasi-judicial body appointed by the Governor, is responsible for setting water quality standards for the Bay-Delta system and the granting of permits to the development agencies for water rights. Pursuant to this, hearings have been conducted over the past few years.

On July 28, 1971, the State Water Resources Control Board issued The Delta Water Rights Decision 1379, in which it formulated the State Delta Standards (123). The Board found that in addition to the water quality that must be maintained in the Delta to satisfy vested rights, "the public interest requires that all beneficial uses of water in the Delta be protected . . . including . . . preservation and enhancement of fish and wildlife." The Board established water quality standards which it estimates will require an average annual outflow of about 3300 cfs during a normal year and about 2600 cfs during a critical year. Also, it required the establishment of an extensive monitoring system by CDWR and USBR and the continuation of ongoing studies.

The Board took no position on the Peripheral Canal (124). Rather, it states that if future project deliveries are not to be curtailed, either a cross-Delta transfer facility will be needed or other sources of water must be generated to augment the combined project yields. At the same time, however, the Board failed to take cognizance of the relationship between Delta outflow and water quality in the South Bay.

We are now in a position to use the concepts available on the physical and biological effects of reduced freshwater flow to attempt a prediction of the future. We will first discuss the physical effects, then the biological effects, of reduced flow. Finally, we will discuss the biological effects of nutrient enrichment.

VII. Effects of Water Diversion on Sediment Flow Into the San Francisco Bay-Delta System

A. Physical Effects

1. Sediment Reduction

There is a definite relationship between sediment flow and freshwater flow in the Bay-Delta system (See Figure 5-3). The greater the river discharge, the more sediment that is carried per unit volume of water. Organic and inorganic materials in solution, suspension and traction (bed load) are transported to the

Bay-Delta system by tributary streams. The finest suspended sediments of colloidal size (less than 0.1 micron) will remain in suspension in fresh water indefinitely. In saltwater, however, these clay particles are flocculated by the positive ions and tend to settle to the bottom if not held in suspension by turbulence. Coarser materials (mostly silt and fine sand) are held in suspension and transported by turbulence of flowing water. The coarsest material (mostly sand) is transported as bed load.

Average daily flows and sediment loads have been measured and published by the U.S. Geological Survey for the water years 1957-1961 (125). The streams which flow into the Bay-Delta system now carry approximately 16,000 tons of sediment a day, the coarsest material as bed load, and the finer material (about 90%) in suspension (125). More than 80% of this sediment comes through the Sacramento-San Joaquin Delta (Table 5-2).

Using data from the U.S. Geological Survey, the Army Corps of Engineers and the Bureau of Reclamation for average annual sediment loads to the Delta over the period from 1924 to 1961, the Army Corps of Engineers adopted a figure of 7 million cubic yards as the average annual sediment inflow to the Delta (127). Both the U.S. Geological Survey and the Corps conclude that the development of upstream storage facilities (without water diversion) will not greatly modify the net sediment inflow to the Bay-Delta (128, 129).

As the fresh water of the river mixes with the salt water of the Bay-Delta system, flocculation occurs. The location depends upon the salinity gradient, which in turn depends upon the fresh water inflow. It appears that much of the new sediment is initially deposited (by shoaling) in Suisun or San Pablo Bays (130). A portion of the sediment is resuspended by wave action and dredging and redistributed by currents. The annual sediment inflow that reaches the ocean is now known exactly and has been estimated as upward of 30% of the total (131, 132).

In 1966, R. B. Krone prepared a report for the Federal Water Pollution Control Administration on the effects of water diversion on sediment inflow to the Bay-Delta system. Krone obtained the empirical relation that for the Sacramento and San Joaquin Rivers, the annual sediment production is exponentially related to annual water discharge (133).

The San Joaquin River has a much lower flow than the Sacramento. Since data for both rivers fit the same relation, it provides confidence in extrapolating Sacramento River loads to lower flows than those observed during 1957-1961. Also, the San Joaquin River basin is more developed than the Sacramento basin. The empirical relation in Figure 5-3 suggests that the total annual sediment loads will continue to be related to the total annual water outflow by the same function even after installation of further regulation facilities. This is in agreement with predictions from the Corps (134).

The relationship obtained between annual water and sediment outflow is used to extrapolate to conditions of reduced flows. These calculations indicate that when proposed water diversions from the Delta are fully implemented, the mean sediment inflow through the Delta will be reduced to just over 1/3 its present value and the sediment flow into the Bay by about 1/2 (Table 5-3). These reductions would be even more drastic during years of minimum flows, and the median sediment inflow through the Delta

would be reduced to less than 1/6 its present value (135). There will be long periods of very low sediment inflow. Krone's estimates are based upon a number of assumptions, including the annual averaging of water

Table 5-2

Average Daily Sediment Inflow

Source	Total Sed. *		Suspended Sed. *		Suspended Particle Size Distribution†		
	Tons/day	% Total	Tons/day	% Total	Sand (>64μ)	Silt (4-64μ)	Clay (<4μ)
Sacramento R.	12,030	69.4%	11,390	70.8%	43%	29%	28%
San Joaquin R.	1,500	8.6%	1,300	8.1%	28%	34%	38%
Other Delta Streams	697	4.0%	573	3.6%			
Streams directly tributary to Bays (Suisun, San Pablo and San Francisco)	3,117	18.0%	2,833	17.6%			
Total	17,344	100%	16,096	100%			

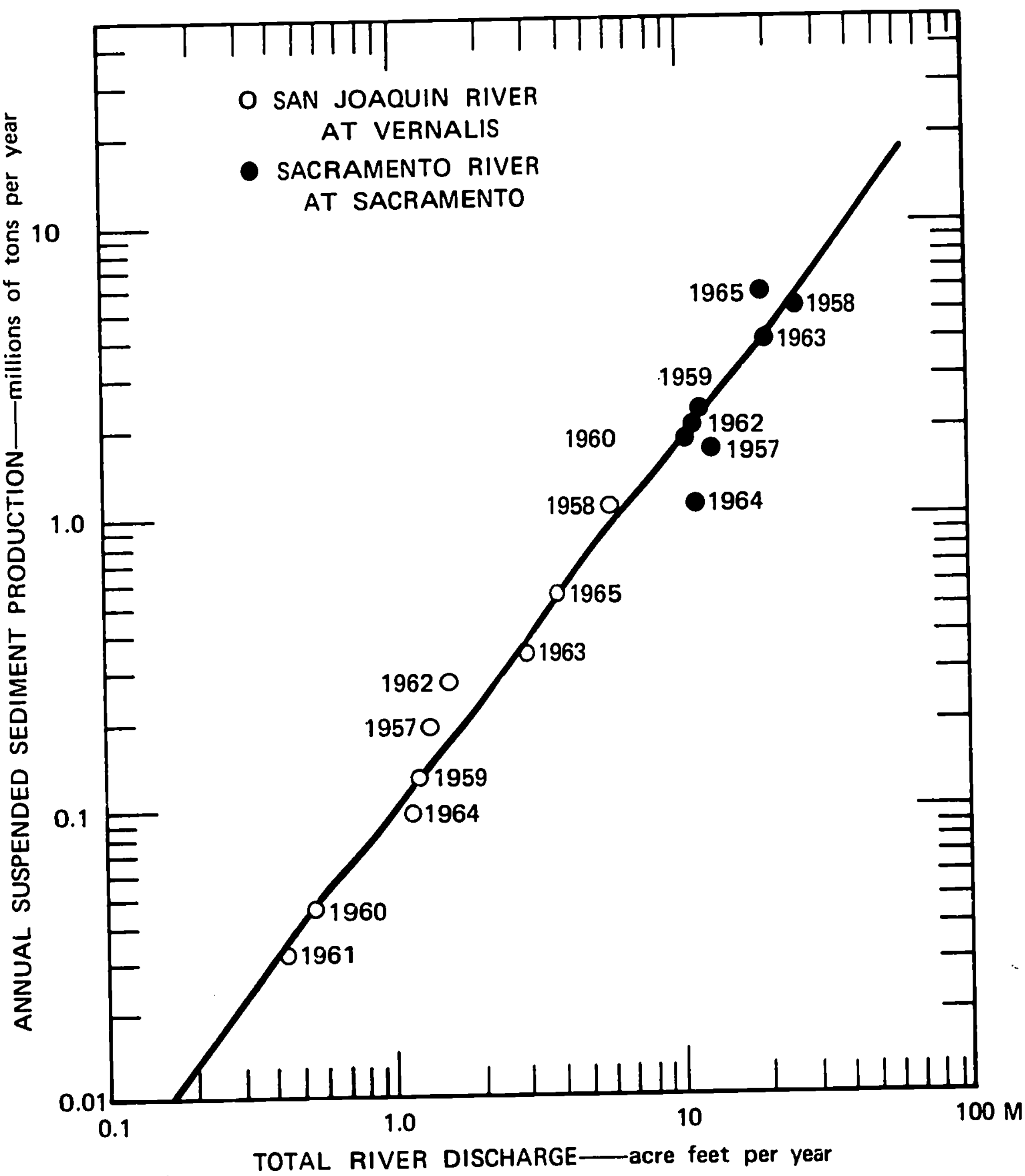
* for 1957 – 59 from Porterfield, 1961
† for 1957 – 66, G. Porterfield, U.S. Geol. Survey, unpublished data

and sediment discharge. A one-year period was convenient since there is an annual cycle of sediment movement mechanisms in the Bay (136). The bulk of the sediment enters the Delta during the winter floods. Krone also assumed that no correlation exists between sediment concentration and water diversion, as no operating criteria regulating sediment release have been announced. Krone used the water diversions as anticipated by the U.S. Bureau of Reclamation (137).

David N. Kennedy, an engineer for the Metropolitan Water District of Southern California, argued that Krone's analysis overestimates the sediment reduction (138). He based this conclusion on two points. First, he stated that the estimates of water diversions are too high, at least as applied to presently pending applications for diversion. On the basis of a statement to the State Water Resources Control Board (April, 1967) by Edwin F. Sullivan, of the U.S. Bureau of Reclamation, Kennedy estimates diversions in 2015 comparable to those estimated by Krone for 1990. In his statement, Sullivan, however, pointed out that "..., there still will remain large surpluses of water in the Central Valley available for additional development." Therefore, there is enough water for additional diversions to take place before 2015.

Secondly, Kennedy stated that a higher percentage of the flow will be diverted during months of low flow (with low concentrations of sediment) than during periods of high flow (with higher concentrations of sediment). Therefore, he concluded that the amount of sediment diverted will be less than that estimated on an annual basis by Krone. On the basis of these assumptions, Kennedy computed the reduced sediment

RELATION OF ANNUAL SUSPENDED SEDIMENT PRODUCTION TO RIVER DISCHARGE



ADAPTED FROM R. B. KRONE
STATEMENT TO CALIFORNIA STATE WATER
RESOURCES CONTROL BOARD, 1970

flows that would have occurred during the five water years 1956-7 through 1961-2. He estimated an average sediment reduction of 31%. Krone's approach (based upon Kennedy's diversions) yields a 46% reduction.

Table 5-3

Estimated Annual Suspended Sediment Inflow in 10^6 Tons/Year

	1960		1990		2020	
	Mean	Median	Mean	Median	Mean	Median
Net sediment inflow from Delta to Bay system (after proposed diversions)	3.35	2.6	1.79	0.7	1.22	0.4
Sediments supplied directly to Bays (Suisun, San Pablo, and San Francisco	1.03		1.03		1.03	
Total	4.38		2.82		2.25	

Modified from Krone, 1966.
Based on diversions anticipated in U.S. Bureau of Reclamation, Hydrologic Data for Central Pacific Basins Comprehensive Water Pollution Control Project, Feb. 1966. This report assumes a minimum Delta outflow of 1,500 cubic feet/second and an annual outflow in 1990 of 5.5 million acre feet, and, in 2020, 2.4 million acre feet.

Kennedy failed to point out that the sediment transported during peak flows will be coarser than that transported during low flows. If a larger proportion of the low flows is diverted, then the sediment distribution reaching the Bay-Delta system will be shifted toward coarser sediment. This means that, based upon total sediment, a disproportionate amount of fine sediment will be diverted. As explained below, it is just this fine material that may be critical to the Bay-Delta system.

In light of these assumptions and the limited data, the sediment flow predictions must be considered as rough estimates. They do, however, indicate significant reductions in sediment inflow and, therefore, indicate the need for further study to refine these figures. Under the Memorandum of Agrement between the California Departments of Fish and Game and Water Resources, and the U.S. Bureau of Reclamation and Bureau of Sports Fisheries and Wildlife, several studies were recommended as necessary to determine the ecologic effects and criteria for proper operation of water diversion projects on the Sacramento-San Joaquin Estuary.

2. Navigable Waterways, Shoaling and Erosion

Physically, reduced flow will reduce the amount of sediment brought to the Bay-Delta. The average sediment inflow to the Bay-Delta is estimated at 8 million cubic yards a year (139, 140). Piers, wharves, dikes, moored boats, jetties, buildings and land fills all affect sedimentation and its settling. In order to

maintain harbors and navigable channels, the Army Corps of Engineers dredges 9 to 11 million cubic yards of sediment annually, at a cost of 3 million dollars. Because the dredged sediment is deposited in deeper portions of the Bay, it re-enters the waterways and 5 million cubic yards of the sediment are redredged each year. Most of the dredged material is bay mud, covering the bay floor to an average depth of about 60 feet. Continuous dredging operations have contributed to the turbidity of Bay waters and have been a significant factor in the destruction of bottom organisms through displacement and suffocation.

The Army Corps of Engineers may not do as much dredging if proposed water diversions reduce sediment inflow significantly. Reduced sedimentation will affect the shoaling and erosion processes of the Bay system, particularly in Suisun and San Pablo Bays. The annual shoaling volume dredged in the North bays averages 4 million cubic yards (141). The shoaling location coincides with the saline-fresh water boundary and occurs in San Pablo Bay, fluctuating on a cyclic basis from west to east with the variable seasonal rate of fresh water inflow. There also exists a long term cyclic movement with the flood-dry year cycle. During dry years with the resulting low inflows from the Delta, the saline-fresh water boundary moves through Carquinez Strait into Suisun Bay where the heavy flocculation occurs rather than in San Pablo Bay. Without adequate freshwater repulsion from the Delta and with stabilization of outflow, the large volume of shoal material might come to Suisun Bay permanently.

3. Light Penetration and Algae

Suspended silt and clay sediments result in turbid water. In addition to this inorganic turbidity, the presence of planktonic algal populations produces an organic turbidity in some enriched areas of the Bay-Delta. Suspended inorganic sediment concentrations in Bay-Delta waters are expected to decrease directly with reduced outflow, and also as a result of decreased resuspension of bottom sediments under sustained low outflow conditions.

If large-scale fresh water diversions from the Sacramento River take place, new sediment inflow to the Bay-Delta will be significantly reduced. In view of the circulation of sediment and its continual movement to places where it can settle and not be resuspended, bottom sediments will become more stable. It is therefore unlikely that tides and waves will suspend the older, more stable bottom sediment as new sediment inflow is reduced (142). Because of the more stable bottom and reduced sediment inflow, Krone predicts that Bay waters will clear during years of inflow and especially during prolonged periods of low inflow (143).

The suspended solids vary in place and time in the Bay-Delta, depending mostly on outflow, the proximity of shallow areas, currents, flocculation and algal populations. Table 5-4 contains suspended solids data for various locations in the estuary.

The average suspended solids concentration for Suisun Bay and the western Delta stations in July 1962, was 57 mg/l and in September 1962 was 50 mg/l. By late October, after some rains, the average level was 72 mg/l. A level of 50 mg/l appears to be a reasonable average figure during the dry season. Similarly, light penetration varies greatly through the Bay-Delta. Transparency measurements using Secchi

Table 5-4 (144)

Suspended Solids Concentration: Bay-Delta

Location	Median (mg/1)	Range
Antioch	38.5	29 – 65
Collinsville	54.5	38 – 81
Middle Point	58.5	19 – 106
Martinez Bridge	54.5	9 – 163
Carquinez Bridge (Crockett)	38.0	11 – 180
San Pablo Bay	42.5	11 – 128
Point San Pablo	15.5	6 – 65
Golden Gate Bridge	8.0	5 – 14

disks and photometers have been made by the University of California, the California Department of Fish and Game and the Federal Water Pollution Control Administration. The white, dish-sized Secchi disk is lowered into the water until it is no longer visible. The Secchi disk depth, thus defined, varies from 2 to 3 meters at the Golden Gate to less than 1/3 meter in Suisun Bay.

Suspended sediments in Suisun Bay and the Delta are varied, including inorganic silts and clays brought in by the rivers and resuspended by currents and organic materials of several origins. The organic material includes the living plankton as well as detrital material. The highest suspended solids concentrations are found in the transition zone between fresh and saltwaters (where there exists an estuarine circulation). This is due to flocculation and increased plankton production. The transition zone of many estuaries is more productive than the areas upstream or downstream because of the presence of various nutrients brought together by land drainage and ocean waters. Suisun Bay encompasses the transition zone in the Bay-Delta.

Future projections in a changed sediment regime are based on three factors: 1) reduced sediment flow into the Bay-Delta system with reduced freshwater flow; 2) stabilization of sediments under sustained low flow conditions, lessening resuspension by wind and tide; 3) possible future removal of dredge spoils from the Bay-Delta. The first two factors are directly related to proposed reductions in freshwater flow into the Bay-Delta.

The combined effect of reduced outflow and reduced sediment transport will tend to accelerate the clearing of Bay waters (145) (See Table 5-5). Dredging operations disrupt natural sedimentation processes as more stable sediments in deeper areas are disturbed. Trends to remove dredged sediments from ship channels to ocean or land will also tend to increase water transparency (146).

Reductions in Delta outflow for long periods of time are specified by the U.S. Bureau of Reclamation operations data. As discussed, the effect on sediment concentrations is expected to follow these reduced flows. Based on the flow changes and the bottom sediment stabilization tendencies described previously, and using the value of 50 mg/1 as the predicted suspended sediment solids concentration for Suisun Bay,

the projected 1990 concentration becomes 14 mg/l and the year 2020 concentration becomes 8 mg/l (147). These projections do not include effects of organic matter or flocculation. Sustained low Delta

Table 5-5

Sediments and Light Penetration — Projections

Year	Median Annual Sediment Transport (10^6 tons)	Suspended Sediment mg/1		Depth of Euphotic Zone (feet)	
		San Francisco Bay	Suisun Bay	San Francisco Bay	Suisun Bay
1960	2.6	10	50	14	3
1990	0.7	3	14	50	10
2020	0.4	2	8	70	20

(from San Joaquin Master Drain, App. C, p. 27)

outflow will probably lead to greater salt intrusion which will move the zone of flocculation upstream.

Krone has used the Beer-Lambert law (148), which describes light penetration in water as a function of the concentration and composition of suspended material, and projected inorganic suspended sediment concentrations to calculate light penetration in the water. The depth of the increases in water transparency due to reduction of suspended inorganic sediments will permit light to penetrate much deeper into Bay-Delta waters than at present. This enlargement of the euphotic zone will, in turn, permit the growth of larger algal populations which themselves create turbidity. The overall effect of this growth on water transparency will depend on the nutrient level, water temperature and other factors related to algal growth. Such algal blooms could be a serious problem, lowering dissolved oxygen levels and producing hydrogen sulfide.

4. Adsorption of Toxic Materials

Very small particles, such as clay, have a large surface area to volume ratio and adsorption occurs readily on their surface. The fine clay particles in suspension act as ion exchangers for a variety of chemicals in solution. Phosphorus and heavy metals can be collected on the particle surfaces and then deposited on the bottom (149). Radioactive elements can be removed similarly (150). These substances have effectively been removed from the system, if the sediment remains undisturbed. Some organic matter, such as insecticides, metabolites and other biologically active materials in the Bay-Delta are likely to be adsorbed to the surface of the inorganic sediment particles and hence, may also be removed from the system (151). On the other hand, sediments tend to maintain a chemical equilibrium with the overlying water and can recharge it with nutrients or poisons. A major reduction in the sediment load may cause a marked change in the organic and inorganic chemistry of the system.

The average adsorptive capacity of new sediments entering the Bay-Delta is quite large. Krone esti-

mates the present ionic sorptive capacity at 6×10^8 equivalents (ionic weight in grams/ionic charge) per year (152). Partition coefficients, a ratio used to identify chemical compounds for various toxic substances between bay sediments and bay water, have not been determined. More study is needed to determine what materials are currently being removed from bay waters by this process and what effect a reduction of sediment inflow will have.

For example, it has been reported that mercury concentration in water is rapidly reduced by sorption and complexing with clays and other colloidal materials (153). Recent measurements on the surface sediments in the Bay estuary system show a variable mercury concentration with a median of 0.2 ppm (70% between 0.08 and 0.52 ppm)(154). Some of the mercury is undoubtedly brought into the Bay-Delta with the sediments while some originates within the Bay-Delta system. At this time, the relative sources of this mercury have not been ascertained, nor has the effect of reduced sediment inflow.

Experiments have been performed where fine sediment (silt and clay), capable of adsorbing toxic substances, have been added to cultures of oyster and clam larvae. More rapid growth was observed in cultures subjected to fine sediment than in control cultures without sediment. (155). This growth occurred because oysters and clams are filter feeders, who do not ingest inorganic particles. In the face of pollution in the Bay-Delta, the adsorption of toxic substances by heavy loads of silt and clay may account for the survival of these and other filter feeding benthic organisms. These experiments should provide the basis for future studies on the role of sediment in larval stages of estuarine benthos. Studies of reduced capacity to assimilate toxic wastes have been recommended by the Department of Water Resources, the Bureau of Reclamation and the California Department of Fish and Game, requiring 5 years and costing $100,000 per year.

5. Dissolved Silica and Diatoms

Dissolved silica (SiO_2) and calcium are present in river water as a result of soil drainage. Present river waters hold much higher proportions of silica and calcium in solution than does seawater, so much higher, in fact, that the composition of the sea would change greatly in a geologically short time if these elements were not withdrawn from solution (156). The withdrawal is done mostly by organisms that incorporate these substances into calcareous and siliceous shells.

Silica uptake by diatoms during the summer diatom bloom has been reported at about 0.1 mg/1/day (157). The highest silica concentrations (20 mg/1 occur in the Bay-Delta is found in eastern Suisun Bay during periods of large outflow from the Delta (158). During the spring and summer of 1964, dissolved silica in San Francisco Bay ranged from 15 mg/1 to less than 1 mg/1. Oceanic values 5 to 15 miles off the Golden Gate were less than 3 mg/1, generally.

Typical silica utilization rates apparently can exceed rates of silica supply to the estuary from river inflow. During extended periods of low river inflow, the silica concentration in the Bay-Delta may be limiting to diatom growth (159, 160).

As has been indicated, the physical and biological factors interact in complicated ways. The re-

mainder of this paper will discuss the biological effects of reduced freshwater flow.

B. Biological Effects of Reduced Freshwater Flow

Reduced inflows, such as would be produced by the planned diversions, will influence the properties of salinity intrusion, circulation and residence time, and sedimentation. Much controversy exists among the different government agencies and conservation groups over the amount of water that should flow out of the Delta. In the 1930's, the State of California and the Secretary of the Interior stated that in order to maintain the chloride limit of 1,000 mg/l at Antioch, that 3,300 cfs outflow would be needed (161). Later in the 1950's, the USBR indicated that 1,500 would be adequate to prevent salt buildup in Delta channels (162). Since then the USBR and DWR have considered 1,800 cfs as the satisfactory minimum (163). The Sierra Club suggested a minimum flow of 4,600 cfs (164). The Corps of Engineers recommended an outflow somewhere between 4,600 cfs and 7,500 cfs (165). The point is that no one knows what the inflow rate should be to maintain water quality. It has been recorded, however, that in 1924 and 1931 outflows of 1,100 and 2,100 respectively caused salinity intrusion to Stockton in the south and Courtland in the north (166).

As stated previously, the New Delta water standards established by the State Water Resources Control Board have established 3,300 cfs as an acceptable minimum outflow for a normal year. The effects of this flow level will be monitored and changed if the state quality criteria are not met (167).

The highest average total dissolved solids (TDS) in the Delta from the years 1952 through 1961 was at Antioch (168). The salinity can vary from 150 to 250 mg/l of TDS (mean tidal cycle) during the winter and spring when the outflow is high to 3,000 to 5,000 mg/l in the low summer flows (169). One of the main arguments offered by the USBR for the San Luis Drain discharge is that during periods of low outflow, the drain water salinity is less than receiving waters and will therefore improve the water quality of the Delta by augmenting outflow and repelling ocean salinity (170). However, the Drain is expected to make its own contribution of 700 mg/l TDS when it first begins operation and 3,000 mg/l in 2020 (171). Thus the Bureau of Reclamation "benefit" statement is circular -- we will divert enough water from the Delta so that even agricultural waste water will improve its water quality.

Salinity intrusion could have very adverse effects on the Delta agricultural lands. If the water became too salty, it could force the abandonment of western Delta agricultural land. It is probable that crop yields would decrease, switching to more salt tolerant crops would occur, and irrigating and leaching cost would increase. Most of these procedures would call for the use of an overland supply of water rather than using the Delta water directly as it is used today (172). This points up another logical inconsistency in Bureau of Reclamation policy. Marginal land requiring expensive drainage systems are being brought into agriculture at the expense of losing high quality Delta farmland.

1. Marshes

Salinity intrusion could also adversely effect the Pacific Flyway. The alkali bullrush of the Suisun

Marsh, an essential food source, is sensitive to salinity (173). Salt tolerant plants are inferior food sources for birds (174). The USBR claims, however, that small releases from the Putah South Canal into the Marshland can cut salinity throughout the marsh up to 50% (175). Upon further investigation into this claim, it was found that the Suisun Marsh studies were "informal" and canal releases depended on whether Lake Berryessa had sufficient water storage (176).

2. Marine Foulers

With an increase in residence time of salinity intrusion, fouling organism nuisance can be expected to increase. If the salinity gradient is moved upward in the Delta and the flushing action is accomplished over a longer period of time, the organisms will have a better environment than present for survival. This will increase maintenance costs for boat owners of the Delta.

3. Effect on Fish

The salinity gradient and concentration has numerous potential effects on fish. High concentrations of TDS (350 mg/l) can block migration of the striped bass and 180 mg/l can affect spawning (177). DFG states that the TDS concentration of the Sacramento River from Three Mile slough to the Peripheral Canal and of the San Joaquin River from Big Creek to Venice Island should not exceed 180 mg/l from mid-April through mid-June (178).

Salmon runs of the San Joaquin River used to exceed 100,000 fish. Flow reduction, salinity gradient reversals, and loss of spawning ground from dam construction have greatly reduced the run. The remains of the fall run are confronted with extinction from the "pollution block" near Stockton (179).

The opossum shrimp *Neomysis* are also threatened with salinity problems. Salinity intrusion must be kept seaward of Chipps Island in order to protect them. CDWR believes that this level of maintenance would require an unreasonable amount of fresh water (180).

Threats emerge from changes in the direction of flow and water quality, for they are both guideposts in migration. While no one has discovered the mechanism by which salmon guide themselves in their upstream migration, it is possible that two systems exist, one for ocean and one for fresh water. The changeover would be important in an estuarine gradient, and one wonders what would happen if the estuary became saltier (181). The instinct to return to the place of birth is so strong among the salmon species that they will die trying to migrate through a blocked stream. It seems that the fish are able to find their way back to their home tributary by differentiating the "odor" of the different streams. Odors are volatile aromatic compounds which are "imprinted" on the young as they move downstream (182). The Sierra Club warns against the confusion that may occur when Sacramento River water is released along the total length of the Peripheral Canal, unrelated to its original source or home tributary (183).

When migrating downstream, young salmon must go through a gradual transition from fresh to salt water. It has been found that the estuarine gradient is used as a directional cue in seaward migration. The ability is related to size and development (i.e., the fish must be physiologically ready). There is some

evidence that downstream migration is passive and is related to the flow rate. It has been found that the number of young salmon moving downward is roughly proportional to the flow (184). Striped bass also require a flowing system in their migration and efforts to establish them in lakes or in slack water have not been successful (185). So far, it is not known how much or what will be the results of reduced flow. Yet, if an organism has certain physiological demands, they must be considered if it is going to survive.

4. **Decreased Sediment Flow and Algal Growth**

Decreased sedimentation resulting from decreased fresh water inflow could have significant effects. It is expected that the euphotic zone will deepen and consequently algae production would increase. With a decrease in turbidity and a combined increase in nutrients which will occur because of the San Luis Drain, a definite increase in blooming would be expected (186). With decreased sediments, it is expected that Si will become limiting for diatom growth; this could change the dominant algae genera; the effects of this occurrence are unknown (187). Laboratory experiments have shown that under conditions of reduced freshwater flows, blooms of dinoflagellates may be apparent as their mobility becomes an asset (188).

Striped bass are cannibalistic and will eat their young. The turbid water helps to hide the fry. The DRG suggests that with a decrease in Delta turbidity, the older bass will be eating more of the younger bass (189).

Another effect of reduced sediments will be the decreased availability of a source on which toxic materials could absorb. Pesticides could be a crucial consideration, but the trend toward eliminating use of chlorinated hydrocarbons, with an increase in the use of thiophosphates and carbamates could help to mitigate this problem. Chlorinated hydrocarbons are not water soluble and are long-lasting, whereas thiophosphates and carbamates are quickly degraded. Although there may be a trend toward increased pesticide use, the amount of pesticide residue may be expected to decrease (190).

5. **Relationships and Effects of Nutrient Enrichment**

The main part of this section is based on the assumption that N is limiting in certain parts of the Bay-Delta system, specifically Suisun Bay and Western Delta. The result of N or other nutrient enrichment – the lowering of DO levels through biological activity – is the final measure rather than nutrient concentration. A high N concentration indicates conditions leading to low dissolved oxygen conditions.

It has been predicted that by 1995, with a Delta outflow of 1800 cfs and no agricultural drain, the N concentration throughout the Delta will increase 50%, with some specific areas increasing 110 to 160% (191). The average N concentration is estimated at 1.6 to 2.2 mg/1 with some regions approaching 3.0 to 4.0 mg/1 (192).

The concentration of N from the San Luis Drain is expected to be 20.0 mg/1. The Kaiser Engineer's Bay-Delta Report stated that untreated and unrestricted, the Drain would account for only about one-half of one percent of the N from all sources (193). Yet, this is one-half of one percent of the N for the *whole* San Francisco Bay and Delta estuarine system, not just the Delta region (194). The Bay-Delta

hydrologic system is not a homogeneously mixed sink. Because of entrapment, estuarine waters will build up a higher concentration of nutrients than either the inflowing fresh water or the more saline parts of the Bay. Therefore, the increased N load from the Drain will have a greater effect on Suisun and San Pablo Bays and the Western Delta than the other parts of the Bay.

In response to the FWPCA report of 1967 (*San Joaquin Master Drain*), an interagency study (USBR, CDWR, FWPCA) was initiated for the removal of N from Drain waters. It was to be a three-year study starting in 1967, and at present, the results are being compiled and evaluated (195). Any of the three methods intensively studied are capable of removing 90% of the N. This would bring the 20 mg/1 N in the Drain water to the acceptable 2.0 mg/1 recommended by the FWPCA as maximal satisfactory N concentration (196).

Two of the three methods deal with biological denitrification. This calls for changing the N in waste water from nitrate (NO_3) to nitrogen gas (N_2) which will then escape into the atmosphere. Bacteria are utilized to change NO_3 to N_2 under anaerobic conditions (absence of DO). Specifically, water passes through a filter, or deep ponds, and prolific bacterial growth in the absence of oxygen removes the oxygen molecules in the nitrates, freeing the nitrogen for release (197).

The other method, algae stripping, involves the use of shallow ponds where the nitrates are consumed by algae. The algae are allowed to grow and are then harvested by filtration, sedimentation, skimming, centrifuging, or other means (198). Desalination was another method studied although it did not seem a promising method of removal (199).

At present, the USBR is determining the method or combination of methods most practical and economical for use (200). The agency has indicated that it is still undecided whether it will use a denitrification process. No attempts have been made to reach conclusions regarding the overall control of nitrates and whether that step is necessary or not (201, 202).

Whatever the direct cause of enrichment, the "increase in waste and drain loads and the decrease in net flows will hasten the process of eutrophication." (203) At present, the most serious enrichment problems of the Delta are associated with the San Joaquin River and specific localized areas of waste dischargers having little or no net fresh water flow. Problems usually occur in the late summer (204). As described earlier, eutrophication brings with it DO reductions. The DO level in the water is an important aspect of water quality for the survival of fish.

There are two effects of DO reduction: lethal limit (concentration below which fish die) and sublethal (resulting in more subtle effects). The fish may die directly of a low DO level or they may die from the increased toxicity of elements under low DO conditions. The mortality to low DO is a function of the species of fish, its physiological condition, and the temperature of the water. Anadromous fish are the most sensitive to oxygen requirements of all Bay fish. In general, as the temperature increases, the DO concentration lethal to fish also rises (i.e., more DO must be present). This relationship occurs because higher temperatures increase the metabolic rate of the fish; increased metabolism means increased oxygen consumption. The physical property of water compounds this problem since an inverse relationship exists

between water temperature and DO: the higher the temperature, the lower the DO. Excessive CO_2 from sewage effluents reduces the oxygen-transporting ability of the fish's blood (205).

Any reduction in DO decreases the oxygen available to the fish's tissues; metabolism and activity must decrease, placing the fish at a disadvantage. Fish can be gradually acclimatized to tolerate low DO levels that would normally asphyxiate them. Under these conditions, however, they must remain almost completely quiescent. Spawning activity requires an oxygen consumption maximum and is therefore affected by DO. Just as some men run from a smoke-filled room, fish avoid areas, such as sewage outfalls, where DO is low. Finally, sublethal DO levels are considered to influence some diseases in fish. A fish kill of several thousand shad at Stockton in 1966 was believed to have been the synergistic effect of a bacterial disease and low DO concentrations (206).

Six mg/l dissolved oxygen has been selected as the lethal limit for fish in the Bay-Delta. However, the tolerance limits for fish food organisms are also important.

The opossum shrimp are more sensitive to DO concentrations than are its predators. If the water temperature is less than 18°C, 5.0 mg/l DO are needed. From 18° to 22°C, 6.0 mg/l are required. Yet, if the temperature is greater than 22°C, no less than 8.0 mg/l DO are necessary to maintain the opossum shrimp (207). Unfortunately, the main nurseries for the striped bass are in deep channels of Suisun Bay where opossum shrimp are *and* where there are increased likelihoods of DO depression (208).

Both the effects of reduced dissolved oxygen levels and their causes must be studied. Unfortunately, "financing [studies of reduced DO] is difficult because no one wants to admit they have any hand in its cause." (209)

C. **Economic Results of Reduced Freshwater Outflow**

The preceding discussion has been concerned with the physical and biological changes as a result of reduced freshwater flow in the Bay-Delta system. However, most water development plans until recently have discussed only the direct economic effects on people living in the area, ignoring changes in the ecological system. We are moving away from this tunnel-vision planning, realizing that man is affected by more than just economic changes.

Still, economic studies are an integral part of water resource planning. In this context, it is useful to summarize one report which studies some of the economic effects of reduced freshwater outflow. The engineering firm of Metcalf and Eddy, in a report prepared for the Contra Costa County Water Agency, has calculated the economic detriment to the county of the decreased quality of offshore water (210). They project the ultimate levels of county development possible with beneficial water quality and determine the net detriment to the county of several adverse offshore water conditions. Given a salt line of 1000 parts per million (ppm) salinity at Jersey Point during average flow years, and allowing for relaxation of this requirement in dry years, as USBR and CDWR proposed on November 19, 1965, Metcalf and Eddy calculate the annual net detriment to the economy of Contra Costa County to be \$4.3 million at the present level of development. Moreover, the present annual detriment to recreation in the county would be

$292,000. They estimate a possible increase to over $8 million by 2020 due to an increase of recreation facilities in this area.

Further estimates of economic damage include costs incurred from marine foulers that may become more established with saline intrusion. The most serious damage would be to waterfront structures constructed of timber. The expected potential loss to waterfront structures located on the Contra Costa County shoreline between Pittsburg and one mile east of the Antioch Bridge would total $3.8 million.

These figures give a ballpark estimate of the economic detriment of reduced freshwater outflow to the Bay-Delta. While Contra Costa County will probably be the most directly affected, it should not be assumed that the other counties surrounding the Bay-Delta will not experience economic changes.

D. Conclusion

An estuary is a complex physical and biological phenomena. The mixing of fresh and salt water forms a unique environment that differs from both ocean and river. The salinity range is the most important environmental factor in an estuary. The brackish condition of the water is responsible for the flocculation and recycling of particles suspended in the river water, resulting in a longer residence time in the estuarine zone. This latter phenomenon generates the increased biological productivity so often noted by ecologists.

The salinity range varies geographically and temporally. The physical mixing of ocean and river provides the smooth gradient of salt concentration characteristic of an estuary. Temporal variation of salinity occurs on both a daily and seasonal basis; the tidal cycle produces the diurnal change, while variation of the freshwater outflow with the time of year causes seasonal changes. It is very important to realize that estuarine organisms have adapted to a salinity range, rather than a salinity average. The range of salinity fluctuation is the most important selective factor on organisms attempting to live there; those with wide salinity tolerances will be greatly favored in the estuarine environment. This selection has produced similar biological communities in most estuaries.

Change is the nature of all living things. Human activity brings about change at a high rate, while geological processes act more slowly. Change is neither inherently "good" or "bad." We assign these values, and they can be changed at any time. A factory, whose discharges may bring about substantial change in the receiving waters, at one time was considered "good." Now, a growing portion of our society feels just the opposite. Likewise, fire prevention in our national parks was considered a noble endeavor. This still seems true to the great majority of our society, yet many park management experts now realize that fire is a natural and necessary agent in the forest ecosystem. The concept is changing from fire prevention to fire management. Perhaps at some future date eutrophic lakes may even be considered "good." The one basic difference between natural change and those caused by man is that human activity, including human value systems, can be altered fairly easily. In this context, the physical and biological modifications resulting from increased freshwater diversions from the Bay-Delta system are not controversial in themselves. It is our values which create the controversy and which must be discussed.

The Bay-Delta is not a natural system. In the past century extensive development has occurred

transforming the area from marsh and tidelands to agricultural land and urban centers. The question facing us now is not whether we can maintain the Bay-Delta as a natural system, but whether man will be able to adjust himself to become a functioning member of a healthy ecosystem. Water development in the Bay-Delta has proceeded with minimal environmental information. This displays the prevalent philosophy that man is somehow separated from the physical and biological world. This is a false and dangerous presumption. Man is the primary element of change in the Bay-Delta system. But it is impossible to extrapolate from this fact that he is not part of the web of life. Just like every other organism, man is dependent upon the maintenance of the entire system for survival. With this in mind, we may be better able to judge some of the changes taking place in the Bay-Delta system. Contrary to some official statements, fresh water is not wasted in an estuary. Reduction and stabilization of the freshwater flow will result in the selection against some of the present estuarine life forms. It is up to man to decide whether this ecological loss is worth more or less than the short-term material gain accrued through the use of the diverted water.

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Chapter Six

COMPREHENSIVE WASTE WATER MANAGEMENT PLANS IN THE SAN FRANCISCO BAY AREA: THE BAY-DELTA PROGRAM

In Chapter Five we reviewed the likely consequences of reduced fresh water flow into the San Francisco Bay. The major causes of such reduction are and will continue to be be the State Water Project and Central Valley Project. Initially we had hoped that sufficient information would be available so that we could generate a city-by-city cost analysis of the effects the SWP would produce, thus providing more specific information to each of the Bay Area's cities for judging the consequences and benefits to them of this portion of the California Water Plan. Unfortunately, such data are still not available, and the amount of work which should be done to determine these facts is staggering. Consequently, we are left with a nebulous situation in which Mr. Gianelli levels charges at the Bay Area that they should clean up their pollution mess before they protest the SWP, while Bay Area officials retort that the SWP will have a far greater impact than minimal pollution problems which are being solved. Such an atmosphere neither solves the difficulties nor generates understanding of their complexity.

Planning for comprehensive waste water management is a large undertaking, and it is particularly so for the 9-county Bay Area. Presently there are at least 270 dischargers dumping about 900 million gallons per day (mgd) of wastewater into the Bay. This includes domestic sewage from municipalities and industrial wastes containing a wide variety of unwanted materials. Moreover, the wastewater load in the Bay may exceed 1 billion gallons per day (bgd) by 1990, and 2 bgd by 2020. These greater quantities would reflect the predicted population increases, plus increased per capita water use. Also chemical and oil spills are becoming more frequent every year; in 1968, there were 199 reported spills, in 1969, 186, and in 1970, 213 spills.

I. Factors Affecting Water Quality

Because the Bay-Delta estuary is a complex ecosystem, water quality is affected by more than

quantity of wastewater. One important factor is the surface area of the Bay. Much of the Bay is quite shallow; the average depth is 20 feet, while the north and south ends are only 15 to 17 feet deep. Therefore, a high proportion of the water in the Bay is in contact with the surface – that is, the Bay has a high surface area to volume ratio (SA/V). This is important, for oxygen, the element essential for respiration in all plants and animals, is able to enter the water from the atmosphere in saturated concentrations. The churning of waves and wind further aids oxygenation of Bay waters.

A. Changes In Surfact Area to Volume

The surface area of the Bay has not been constant through the years. When Gaspar de Portola's expeditionary force made their way over the Santa Cruz Mountains to discover San Francisco, its 680 square miles could harbor all of the navies of Europe. What Portola did not know then, but what developers and engineers were soon to find out, was that at low tide about 66 percent of the Bay is less than 18 feet deep. In fact, it is so shallow in some places that a man in hip boots can easily walk out to the center of the Bay without getting wet.

Since 1851, when the State of California first sold beach property along San Francisco Bay to the City of San Francisco, Bay tidelands, salt marshes, mud flats, and submerged lands have met the filler's shovel. Thus, as the City of San Francisco grew and needed port facilities closer to the deeper channel water, what could be simpler than filling in some mud flats to get there? Since it was (and still is) much more economical to build on flat land, as opposed to hilly terrain, what could make better sense than knocking a few hills into some tideland? Not only would there be new flat land where there had once been a hill, but Bay water would be "reclaimed" – also, good, flat building land. And since salt marshes are a waste of space, what could possibly be in the better public interest than diking off those useless appendages, turning them into salt evaporators, and when that is no longer economical, just filling in the evaporators and building houses?

Because of such attitudes, in little more than one hundred years, the shape of the Bay and its surface area have changed drastically. A multitude of fill projects, initiated by Bay Area cities, corporations, land speculators, county, state, and federal governments, nibbled away at the Bay shoreline. By 1958, the water-to-land conversion had reduced the area of the Bay from 680 to 437 square miles.

As shallow parts of the Bay are filled in, the SA/V ratio is reduced. Therefore surface reaeration is not as vigorous as previously, and inadequately treated water wastes further lower the dissolved oxygen (DO) concentration. Domestic sewage and other organic waste demand a great deal of oxygen for decomposition.

B. Dissolved Oxygen Depletion

The measure of this oxygen-demanding property of a waste in water is the biochemical oxygen demand (BOD); the less well treated waste water is, the higher its BOD. More oxygen will be taken out of the receiving water and, in some cases, the waste water may demand more oxygen than is present. The result is depletion of DO, the symptoms of which can be troublesome and environmentally damaging. Many

desirable organisms, especially game fish such as striped bass and shad cannot survive under low oxygen conditions. DO drops are considered an important factor in many fish kills. The biological community structure shifts to favor those organisms that can survive under low or absent oxygen conditions. Anaerobic conditions are associated with objectionable odors, which bacteria generate during the anaerobic decomposition of organic matter. DO depletion has been a serious problem in the South Bay, especially in the summer when both domestic sewage from San Jose and cannery wastes enter the Bay.

C. Freshwater Outflow

A third major factor affecting water quality in an estuary is the amount of freshwater outflow. While the amount of salt water pumped into the San Francisco Bay-Delta estuary is constant throughout the year, freshwater outflow shows great seasonal variation. By far the greatest source of freshwater into the Bay is the Delta, into which flow the Sacramento and San Joaquin Rivers (See Chapter Five). Presently, Delta outflow is about 18 million acre-feet per year (MAFY), compared to an historic level of 30 MAFY. The 8 other tributaries flowing into the Bay contribute a combined total of 0.36 MAFY. Delta outflow varies from 1500 cubic feet per second (cfs) in the summer to a wet season flow of 40,000 to 50,000 cfs (36 MAFY). The average yearly flow is thus about 18 million acre-feet. The amount of freshwater flow in the Bay-Delta estuary is important because it controls, to a great extent, the residence time of pollutants in the water. (Residence time is the length of time a particular material remains in one area.) In the North Bay, which is most directly affected by the Delta outflow, residence time will change strikingly with different outflows. At 1500 cfs outflow, materials dumped into the water will remain there for 300 to 400 days before being flushed out, while at 50,000 cfs, the residence time is only 20 to 30 days. The South Bay is different because it does not have a direct freshwater source to provide strong seasonal flushing action. The residence time for materials in the South Bay is about one year. Recent evidence from the U.S. Geological Survey indicates that Delta outflow flushes the Southern arm of San Francisco Bay during the winter months, when freshwater flow is high (See Chapter Five).

Because Delta outflow determines the residence time of pollutants dumped into the Bay, this is obviously important to water quality maintenance. Residence time assumes even greater significance when we consider the projected decreases in freshwater flow which the State Water Project and the Central Valley Project will produce. Freshwater, which otherwise would have entered the Bay, will be diverted through the California Aqueduct to Southern California. By 1990, according to the State Department of Water Resources (DWR), Delta outflow will be about 9 MAFY, one-half the present flow. Water transfer will further decrease this to 7 MAFY by 2020. These reductions in outflow will increase the residence time of pollutants in the Bay. At the same time, agricultural drainage, rich in nitrates and phosphates, is being discharged into the Bay-Delta system in increasing quantities, and the proposed federal San Luis Drain would worsen this situation.

D. Inadequate Treatment

Present water quality problems in the Bay are caused primarily by disposal of inadequately treated wastes. There are several types of problems. First, as has been discussed, there are dissolved oxygen depletions, especially in the South Bay. There are dangers from the discharge of disease-producing bacteria and viruses contained in poorly treated sewage. This problem has improved somewhat since 1967, when more Bay Area communities started chlorinating their sewage. Even now untreated sewage is still discharged during the wet season through combined sewers and storm drains, and from infiltration through old pipes, as well as treatment plant bypass systems, which prevent overloading during high flow periods.

Biostimulation refers to the problem of enrichment of the water with nutrients causing excessive algae growth, or eutrophication. Algal blooms lead to DO depletions and are totally unaesthetic. Biostimulation becomes a more serious problem when sewage undergoes secondary treatment, for complex organic materials in the sewage are broken down into simple compounds such as nitrates and phosphates. These nutrients are more readily taken up by algae, stimulating growth.

E. Toxic Waste Discharge

Industries discharge a wide variety of toxic wastes, including strong acids and bases, and heavy metals. The acute effects of these wastes may be dramatic; in the 6-year period from 1965 to 1970, there were 35 reported fish kills. The chronic effects of toxicants, however, are probably just as harmful over a longer period of time, reducing diversity and stability of the biological system. Persistent toxicants are especially serious because they are able to concentrate in the food web through the process of biological magnification.

1. Pesticides

One particular group of toxicants that is ubiquitous in its presence is the chlorinated hydrocarbon pesticides. In most parts of the Bay, pesticide concentration already exceeds the federal limit of 50 parts per trillion (ppt). Most of these pesticides in the Bay result from agricultural drainage into the Sacramento and San Joaquin Rivers. The proposed San Luis Drain of the Bureau of Reclamation, which would discharge agricultural wastewaters into the western Delta, will further aggravate this problem. At the same time, however, the State has imposed strict limitations on the use of chlorinated hydrocarbon pesticides. It is interesting to note that approximately 20% of the pesticides in the Bay come from municipal and industrial waste discharges.

II. The Bay-Delta Report

A. Historical Background

In the years from 1948 to 1967, the public of the San Francisco Bay region spent $464 million for sewer facilities. This was nearly 30% of the state total. But it was clear that not enough was known about

the various problems, or of methods to alleviate them. Even though there have been significant increases in expenditures in the last 5 years, there is still 3 times as much spent for water supply as there is for waste water disposal. In 1965, the State legislature passed the Water Pollution Control Law, which authorized a study of the water quality problems in the Bay, the objective being "to provide the basis for arriving at a program of waste disposal and water quality control which promises the greatest possible net economic and social returns to people of the region and State."

The newly formed State Water Resources Control Board hired Kaiser Engineers as principal investigators of the *San Francisco Bay-Delta Water Quality Control Program*, although several other engineering firms, schools, government agencies and individuals were instrumental in the study. The specific goals of the Bay-Delta study were: 1) to determine the effects of wastewater and drainage discharges into Bay-Delta waters; 2) to determine the need for and feasibility of a comprehensive multiple-purpose waste collection and disposal system serving the entire area; and 3) to develop the basic features of a comprehensive plan for the control of water pollution.

B. Assumptions

Several important assumptions were made in the course of Bay-Delta study. Population predictions showed substantial growth from the present 5 million to 9 million by 1990 and 16 million by 2020. Corresponding increases in wastewater flow follow. Also, since no treatment process can remove all pollutants from wastewater, and since natural runoff is very difficult to control, dilution was regarded as the best way to deal with wastes. This assumption skewed the decision-making process toward a solution relying on dilution of the wastewater rather than treatment. The results of this $3 million, 4-year study are summarized below.

C. The Plan

The alternative systems studied were: 1) local disposal; 2) central Bay disposal; 3) central Bay-ocean disposal; 4) ocean disposal; and 5) reclamation-ocean disposal (See Figures 6-1, 6-2, and 6-3). Of these, the last was recommended as the best plan. The two key features of this system are 1) transport of non-reclaimable wastes to the sea, and 2) maximum reclamation and reuse of wastewater as supplemental supplies. The design of this system was based on knowledge of biostimulation and toxicity. The Reclamation-Ocean Disposal system would be constructed in three phases, each of which provides enough elasticity to allow for changes in needs or knowledge.

1. Phase I

Phase I, planned from 1970 to 1980, would collect wastewater from Marin, Napa, Sonoma, and Contra Costa counties, discharging it to the central part of the Bay, while wastes from the Southern Bay communities would be disposed of just north of the Dumbarton Bridge (See Figures 6-4, 6-5). Also, a regional treatment plant in San Rafael would provide filtration and chemical treatment for wastes collected

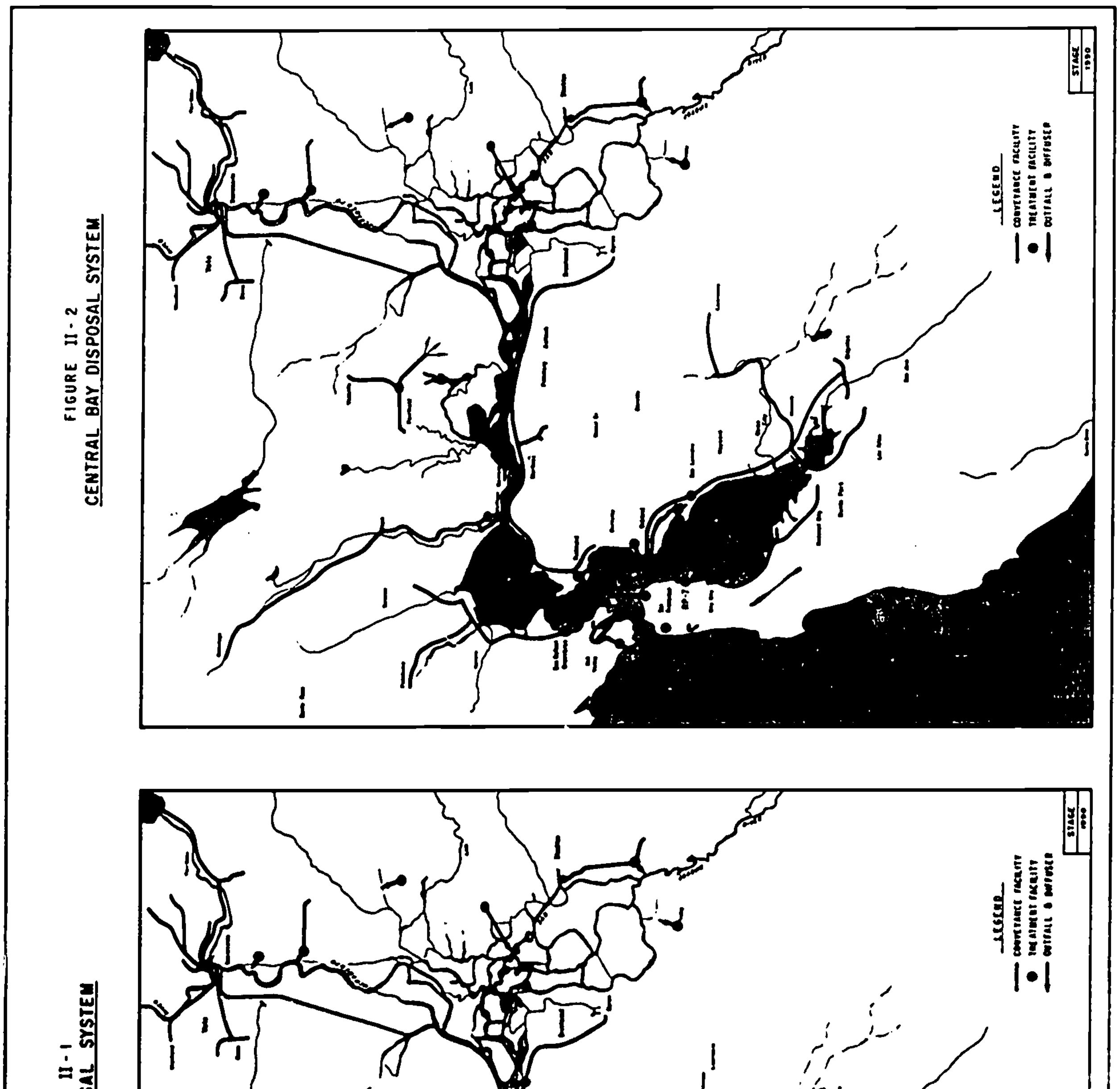
FIGURE II-1
LOCAL DISPOSAL SYSTEM
FIGURE II-2
CENTRAL BAY DISPOSAL SYSTEM
LEGEND
CONVEYANCE FACILITY
TREATMENT FACILITY
OUTFALL & DIFFUSER
STAGE

Figure 6-1

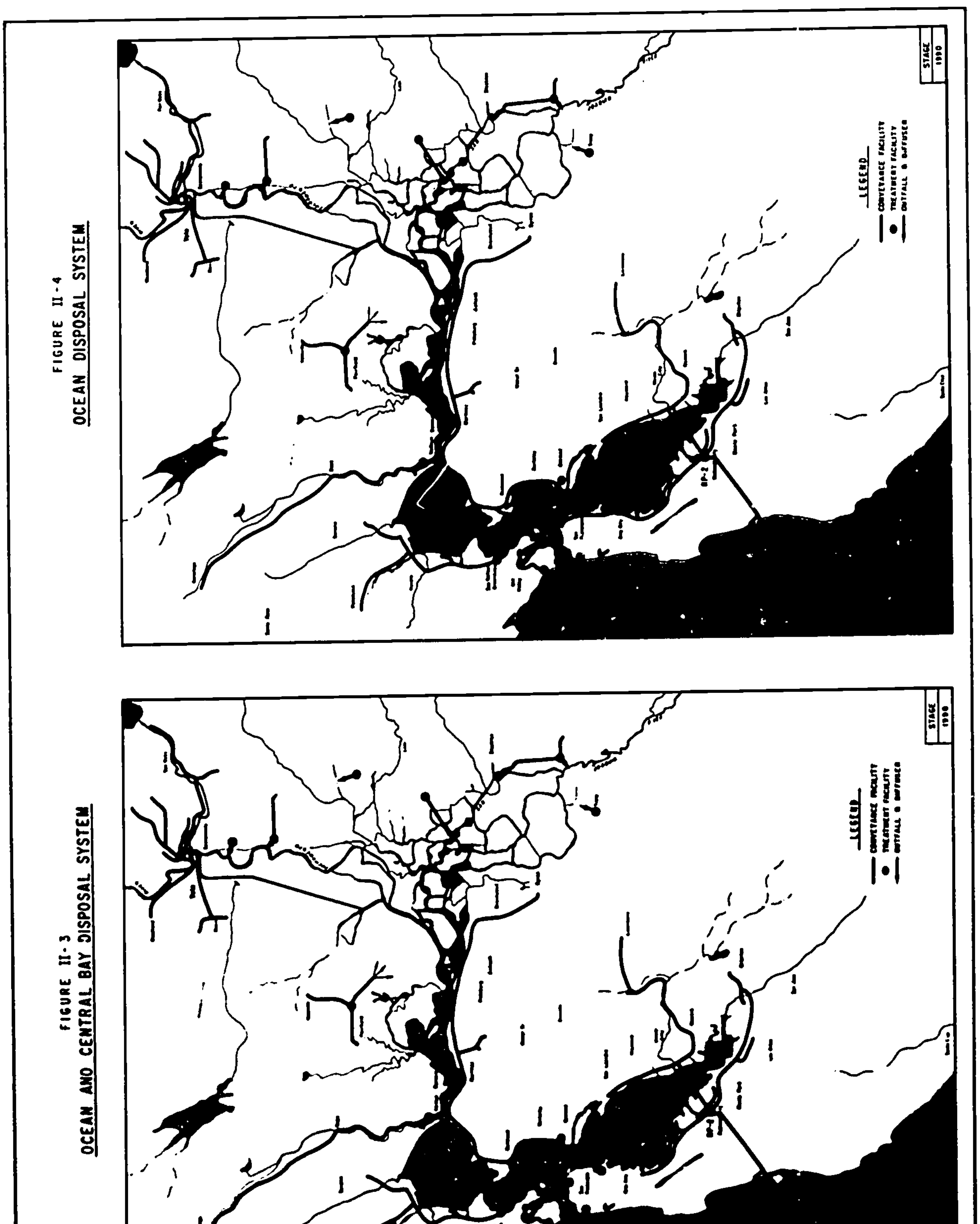
FIGURE II-3
OCEAN AND CENTRAL BAY DISPOSAL SYSTEM
FIGURE II-4
OCEAN DISPOSAL SYSTEM
LEGEND
CONVEYANCE FACILITY
TREATMENT FACILITY
OUTFALL & DIFFUSER
STAGE
1990

Figure 6-2

FIGURE II-5

RECLAMATION – MARINE DISPOSAL SYSTEM

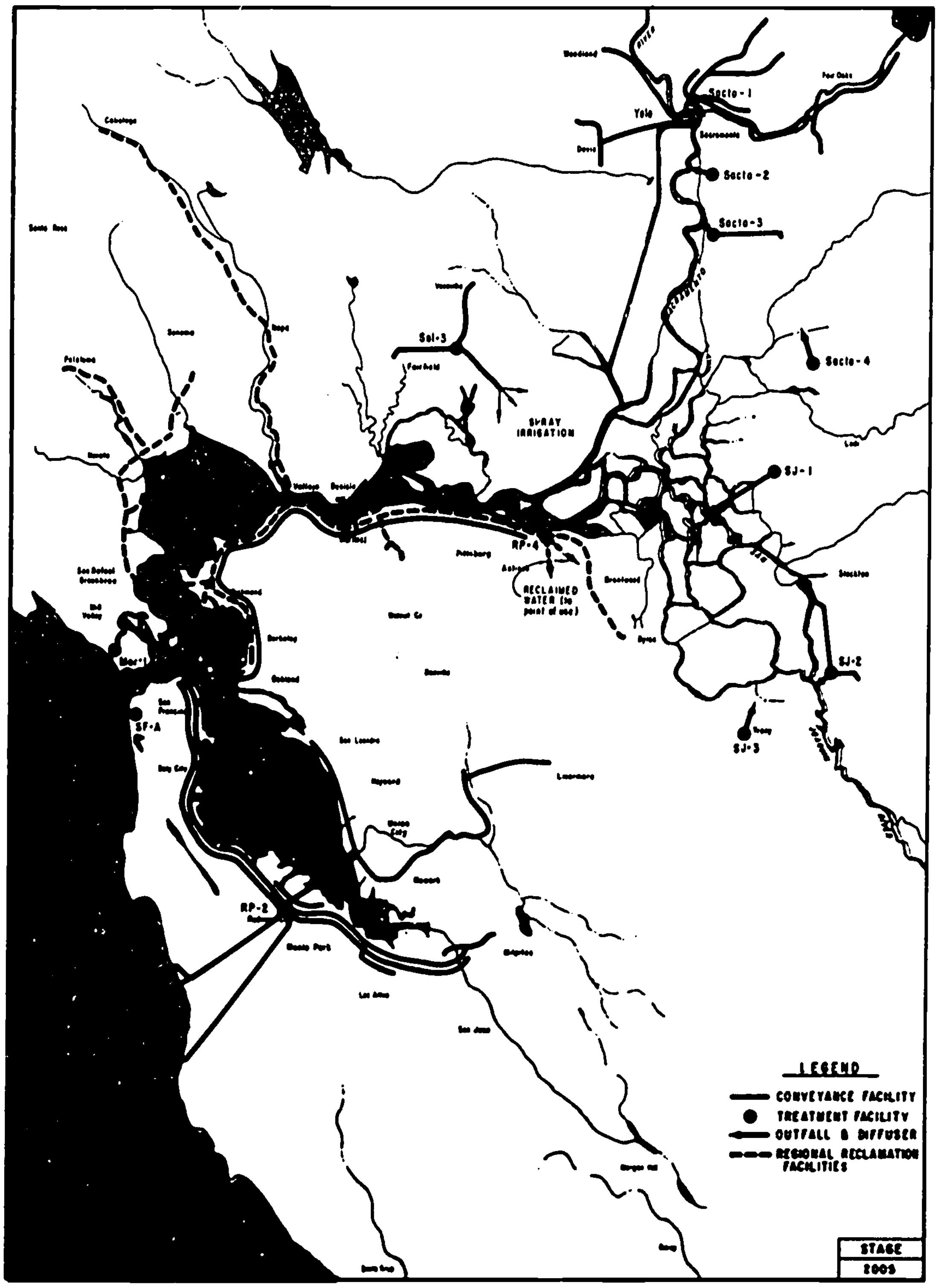

Figure 6-3

in Sonoma County. The projected wastewater load handled by this system in 1980 is estimated at 844 mgd; only 85 mgd would be handled by discrete industries.

Wastes in the Stockton and Sacramento areas would be treated and discharged separately, in order to keep open the option for reclamation. Wastewater from the Fairfield-Vacaville area (Solano County) would be disposed of by secondary treatment at a regional plant, followed by spray irrigation.

The Phase I system would move wastewater out of the critical problem areas now present in the north and south ends of the Bay. It is assumed that the more vigorous dilution capacity in the Central Bay will render the wastes less harmful.

The cost of Phase I is estimated at $750 million. Most of this would be for conveyance facilities. Few present treatment facilities would be upgraded. The primary goal of this Phase is to get wastewater out of those parts of the Bay which are deteriorating rapidly.

2. **Phase II**

Phase II (1980-1990) would eliminate waste disposal into the Bay, transporting it to a regional, advanced primary treatment plant in Redwood City (See Figures 6-6 and 6-7). Following this minimal treatment, the effluent would be piped over the hills to an ocean outfall at Miramontes and Pescadero Points. Individual treatment plants previously discharging into the wastewater interceptors would not be required after 1990.

This Phase would significantly change waste water load conditions in the Bay-Delta system. The facilities would account for 1,071 mgd of the total projected flow of 1,189 mgd, the remainder being disposed of by those discrete industries which treat their own wastes.

By 1980, at the end of Phase I, 719 mgd of wastewater would be discharged into the Bay. Phase II would reduce the Bay load to 274 mdg, while 662 mgd would be released to the ocean. Therefore, over half of the 1,189 mgd of wastewater generated in the area would be removed from Bay-Delta waters. While Phase I would reduce the 1970 BOD load by 30%, Phase II would bring about a further reduction to 85% by 1990. Furthermore, the relative toxicity discharged in 1990 would be less than one-half the 1970 level, even though Phase I will bring about a slight increase in relative toxicity.

According to the Bay-Delta Plan, water quality objectives in the Bay would be met by 1985, provided there is sufficient Delta outflow. The basic assumptions behind this Phase are that 1) a given amount of waste will do less harm in the ocean than in an estuarine environment, and 2) knowledge of tertiary treatment in removing toxicity and biostimulatory characteristics is presently too limited. Furthermore, it is hypothesized that the biostimulating effects of the effluent might be beneficial in the ocean environment, although no evidence was presented to support this statement.

Total capital cost through Phase II is estimated at $1.56 billion of which $860 million (55%) would

FIGURE XXI-I

RECLAMATION - MARINE DISPOSAL SYSTEM

PHASE ONE

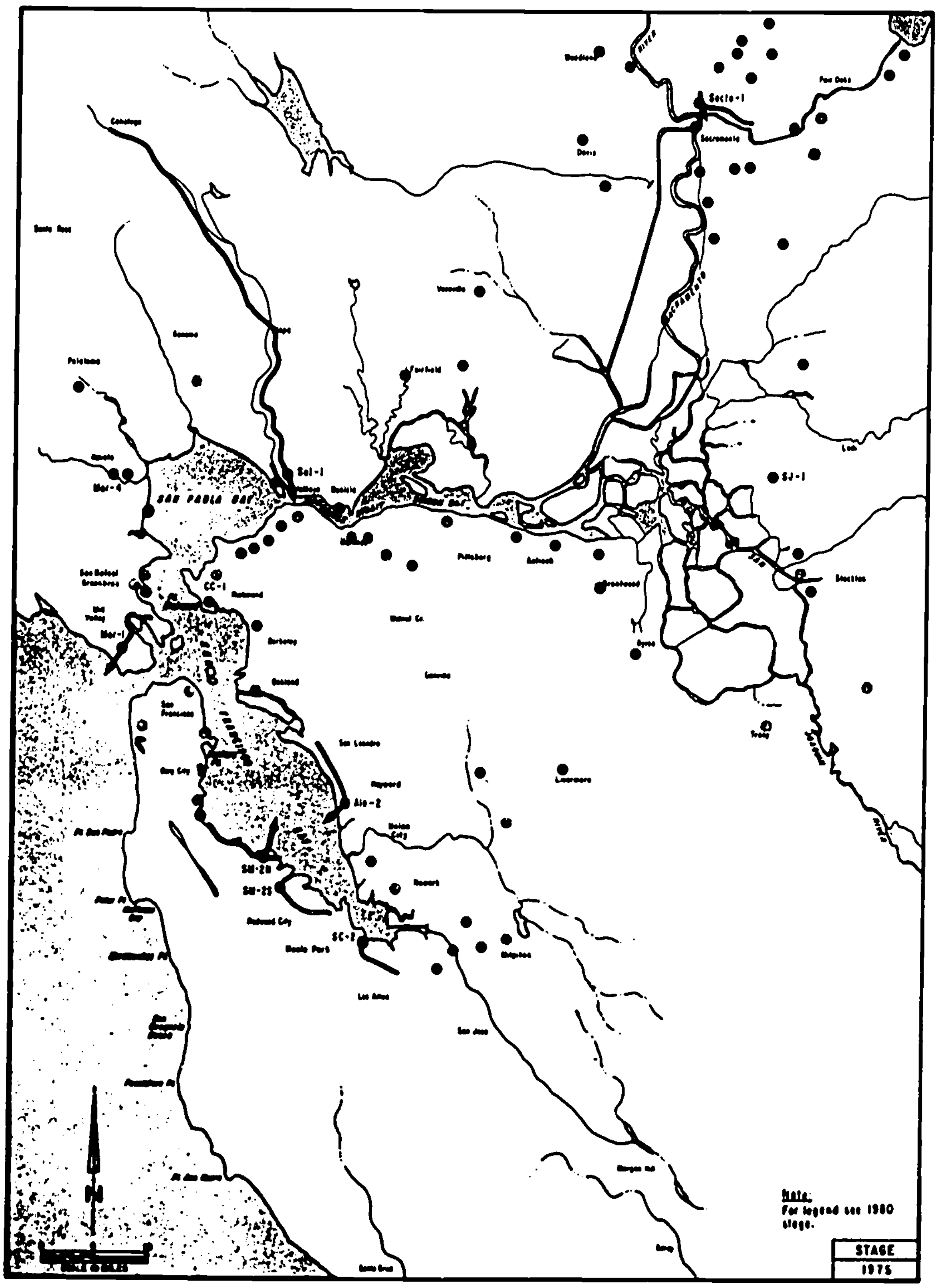

Figure 6-4

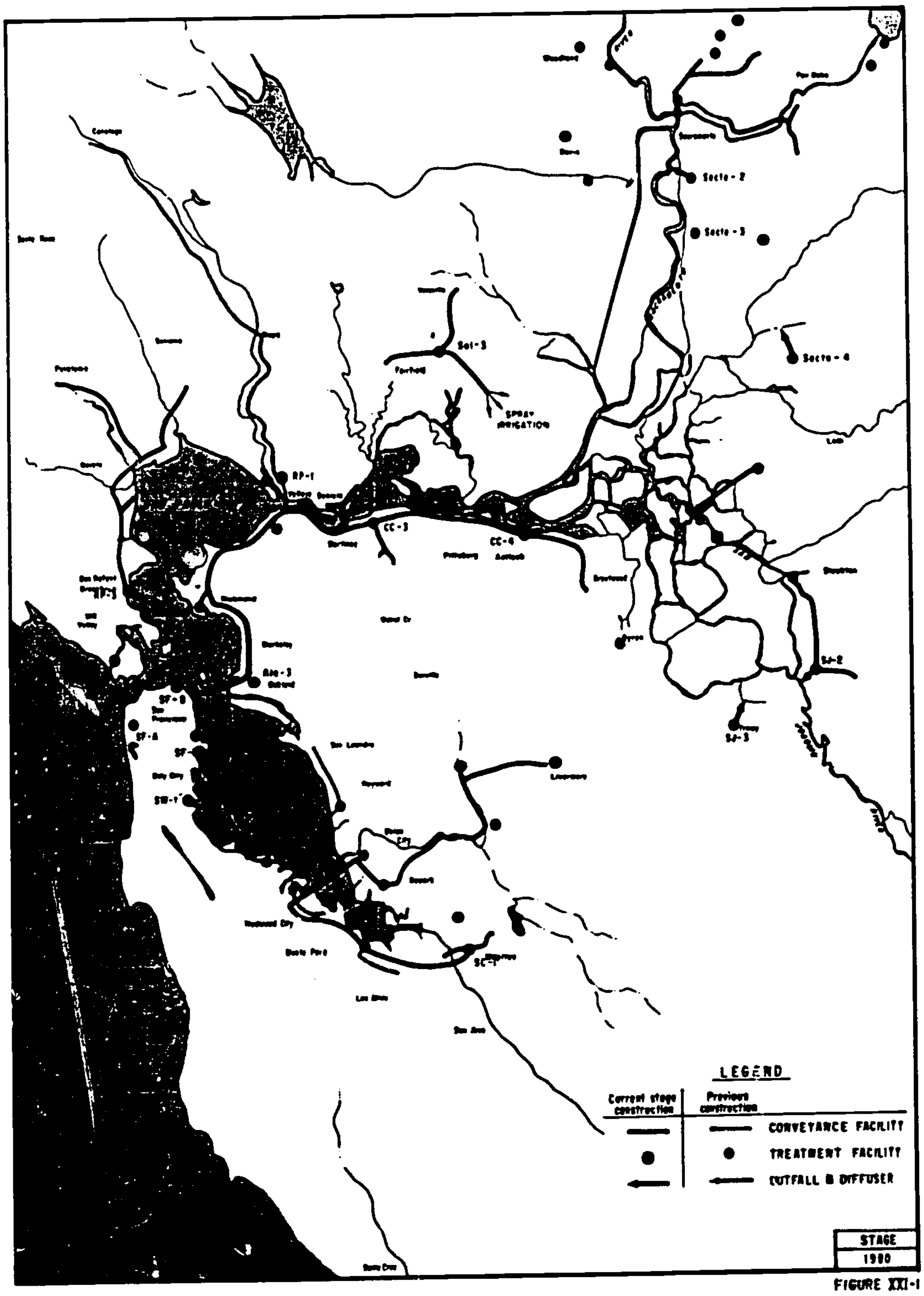

FIGURE XXI-1

Figure 6-5

FIGURE XXI-3

RECLAMATION - MARINE DISPOSAL SYSTEM

PHASE TWO

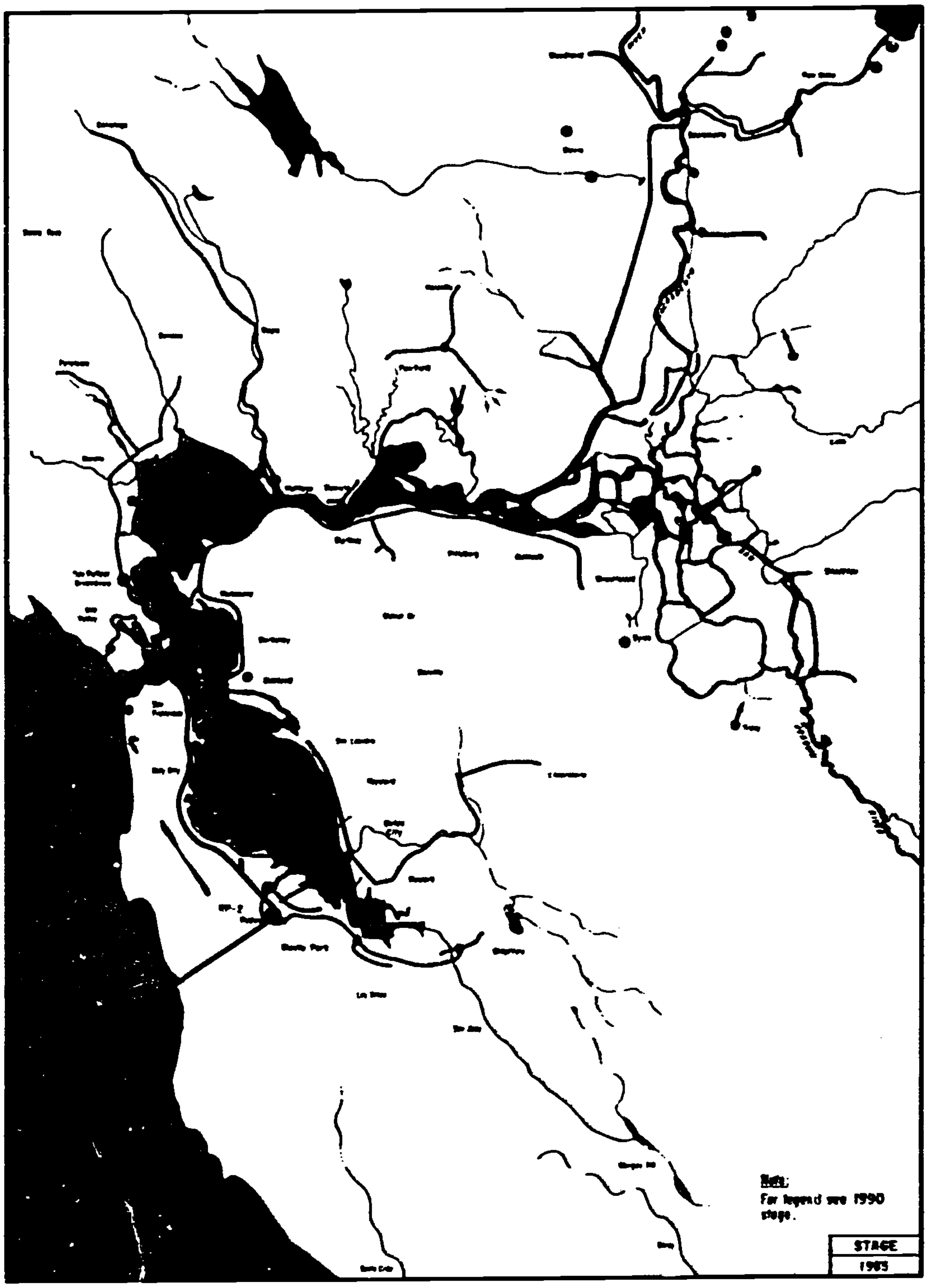

Figure 6-6

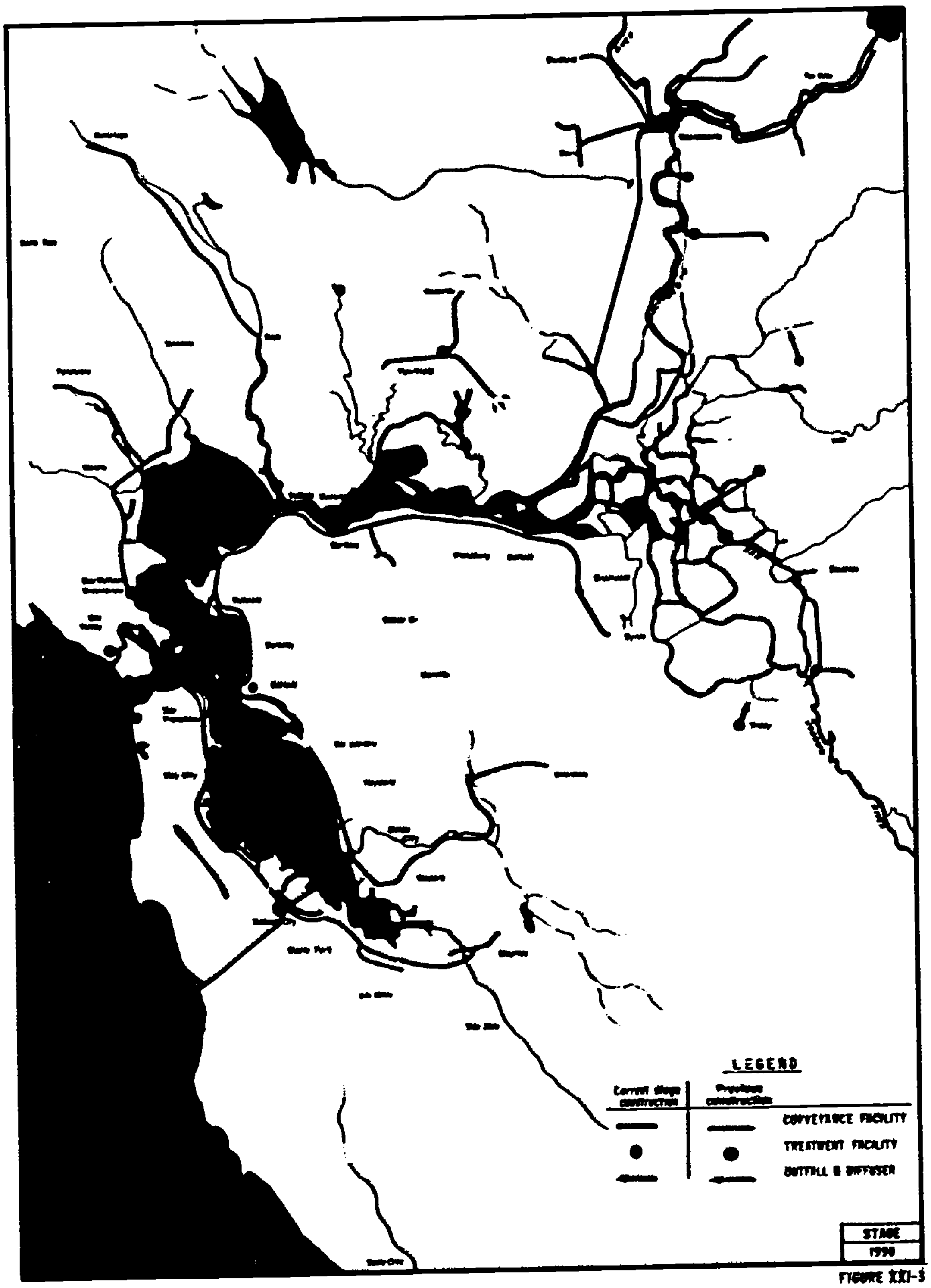
LEGEND
Current stage construction
Previous construction
CONVEYANCE FACILITY
TREATMENT FACILITY
OUTFALL & DIFFUSER
STAGE
1990
FIGURE XXI-3

Figure 6-7

FIGURE XXI-4

RECLAMATION-MARINE DISPOSAL SYSTEM

PHASE THREE (RECLAMATION)

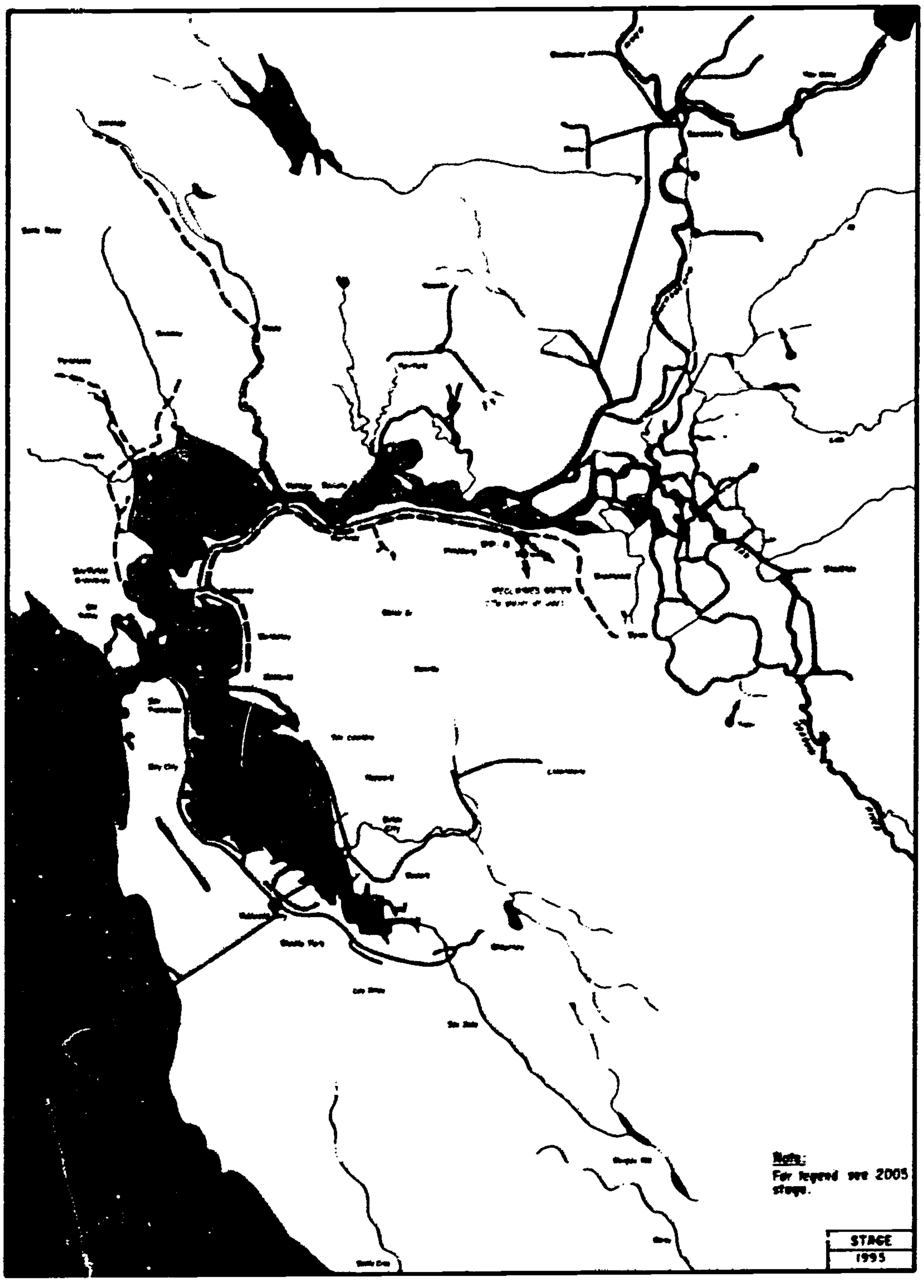

Figure 6-8

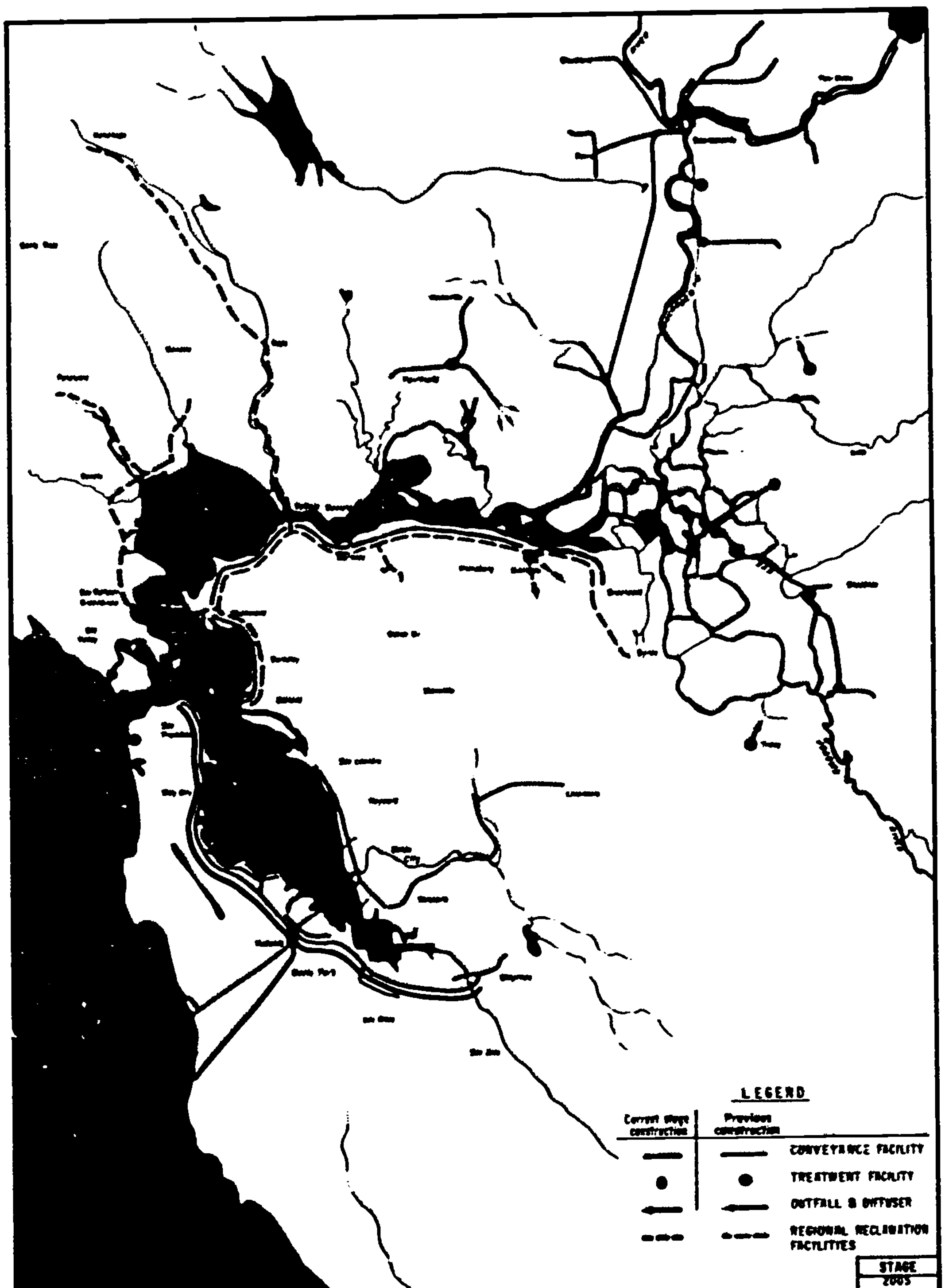

FIGURE XXI-4

Figure 6-9

be used for construction of the major interceptors and regional plants at Redwood City, Vallejo, and San Rafael. $500 million would be needed for local treatment facilities and trunk sewers, and the remaining $200 million would provide for industrial treatment.

2. Phase III

Phase III is not a definite plan, but rather a guide for future planning, since the uncertainties in 50-year planning are too numerous. One goal of the Bay-Delta Plan is to provide for maximum flexibility. In working toward this goal, two main alternative systems for Phase III are proposed: a reclamation option and a disposal option.

The reclamation option rests on the assumption of existence of a market for the reclaimed water and developments of treatment technology so that biostimulants and toxicants can be economically removed. Municipal wastewater is amenable to reclamation, as are certain types of industrial effluents, such as wastes from canneries and paper industries.

The principal features of this plan include a system of pipelines conveying all the wastes from the north and east bay areas to a reclamation plant at Antioch (See Figures 6-8 and 6-9). The regional plant at San Rafael would then be put out of service. The lines toward Antioch would carry only reclaimable wastes: those unsuitable for reclamation would be transported away through the existing facilities. In addition, interceptors parallel to the Phase I lines in the South Bay and Peninsula would be in operation by the year 2000. The regional plant at Redwood City would be expanded to a capacity of 850 mgd, with a second ocean outfall constructed.

Under the reclamation option, about one-half of all the wastewater generated in the Bay-Delta system would be kept within the Delta area, where the value of fresh water is highest.

The total capital expenditure through Phase III is estimated at $2.3 billion (in 1969 dollars), plus about $2.0 billion for operation and maintenance.

The second major alternative for Phase III is the disposal option. This is essentially a plan for extension of Phase II. The basic features of this plan would be the construction of a second East Bay interceptor (Antioch to Oakland, connecting with a pipe across Carquinez Strait that would carry treated effluent from the regional plant at Vallejo, Regional Plant No. 1). From 1995 to 2000 this line would discharge in the Central Bay through the old Phase I outfall. In 2000, the interceptor would be extended across the Bay, south to the Redwood City plant. Regional Plant No. 1 would be taken out of service, and a second outfall to the ocean completed.

The disposal option would be used if a market for reclaimed water did not develop due to economic, technical, or social reasons. The assumptions behind the disposal option of Phase III are the same as those guiding Phase II. While the recommended system was planned for reclamation of municipal wastewater, it was assumed that there would be a demand for reclaimed water only after 1990. According to the plan, water quality objectives in the Bay would be met by 1985, or during Phase II, provided that there was a sufficient Delta outflow.

4. Limitations, Problems, and Errors

The Bay-Delta Report, while doing an important job of pulling much information together, has been strongly criticized for both its assumptions and conclusions. Moreover, certain decisions by the Regional Water Quality Control Board have rendered a few arguments to be of only academic interest. Attention should be brought to some of the more glaring errors, though. First of all, the studies on biostimulation presented in the Report are inconclusive and contradictory (See Chapter Five). From these studies, it is concluded that nitrogen is not a limiting nutrient in Bay waters, an opinion that runs contrary to that of most knowledgeable people in the water quality field in the Bay area.

Errors regarding ocean disposal seem to have been even more serious. Little oceanographic data was obtained. Danger of pollution of Monterey Bay was disregarded, although residents from that area have presented good evidence that ocean disposal of San Francisco Bay's waste would have a strong detrimental effect on their bay. The Report's predictions of the effects of ocean disposal of toxic materials in the marine environment seem to minimize problems that have been encountered with other outfalls, and in general show little understanding of the marine ecosystem or any appreciation for such processes as biological magnification of persistent toxicants.

III. The Interim Water Quality Control Plan

Between the time during which the Bay-Delta Report was written (1965-1969) and the present, important policy changes have occurred. These can best be discussed through an analysis of the San Francisco Bay Regional Water Quality Control Board's *Interim Water Quality Control Plan*. This plan is to serve as a guide for the next 2 years, when fully developed basin and regional plans will be completed. This plan, in other words, is the link between the Bay-Delta Report and the completion of more detailed regional and subregional studies.

This plan meets the new state and federal requirements for construction grant programs and the Porter-Cologne Act requirements for water quality control programs. In order to receive maximum federal and state aid (55% and 25% respectively), it must be shown that the plan will assure the greatest protection of waters and maximum reuse of wastewater as a resource. Moreover, the Environmental Protection Agency (EPA) requires each state to prepare and approve water quality control plans for basins as a condition for future receipts of construction grants.

A. Information Sources

The Interim Plan did not conduct field studies of its own. Rather, it relied heavily on the Bay-Delta Report, the University of California's Sanitary Engineering Research Laboratory (SERL) report "Comprehensive Investigation of San Francisco Bay 1960-1964," and the preliminary output from several of the subregional sewerage studies currently being conducted. For that reason, sections of the Interim Plan are very similar to the Bay-Delta Report, especially the discussions of the area description of present problems. Furthermore, increased wastewater flow and decreased Delta outflow are regarded as the major potential

problems, although it is stated that the State Water Resources Control Board has responsibility for regulating freshwater released to maintain the water quality needed for beneficial uses. (It is interesting to note the increase of wastewater flow into the Bay recorded in the Interim Plan as compared to that in the Bay-Delta Reports: 270 dischargers dumping 800 mgd in 1971, compared to 147 outfalls discharging 660 mgd in 1969. In July, 1971, the State Board established Delta water quality standards, setting a minimum acceptable Delta Outflow at 3300 cfs.

B. Goals

The policy guidelines and goals of the Interim Plan show a shift away from the Bay-Delta Report recommendation that waste dilution be employed while upgrading present treatment facilities. The updated goals are: 2) quality of all the water in the basin is to be continuously maintained and enhanced to the highest possible levels; 2) municipal and industrial wastewater is to be managed as part of an integrated system of freshwater supplies to achieve maximum benefit of freshwater resources and to achieve environmental protection; and 3) the most effective use of freshwater and protection of the environment is to ultimately be achieved through maximum reclamation and reuse.

C. Management Principles

In order to effect these goals, the *Interim Plan* listed several management principles. These principles show the influence of both *The Bay-Delta Report* and also the recent stress on reclamation. The principles are: 1) subregional and regional sewage planning is encouraged as the most effective means of (a) achieving the goals at the earliest date, (b) minimizing investment, (c) implementing consolidation of facilities for better discharge locations, more efficient operation of facilities, and improved reclamation options, and (d) assuring planned growth of sewerage systems; 2) proven methods will be used until alternative methods are adequately documented; 3) reclamation is encouraged as part of subregional and regional programs; 4) discharge of wastewater to surface water is considered (a) an interim means for disposing of reclaimable wastewater, (b) a means for disposing of adequately treated blowdown, or (c) an emergency outlet for peak flows; 5) projects requesting federal and state grants are required to (a) conform to approved subregional programs, (b) to give maximum protection and enhancement of Basin waters, and (c) be supported by ordinances requiring source control of persistent toxicants; and 6) discrete (those treating their wastes separately) industrial waste dischargers are encouraged to (a) reduce the volume of wastewater to surface waters, (b) control toxicants at the source, (c) prevent accidental spills, and (d) use municipal reclaimed wastewater.

The Interim Plan also presented a list of specific water quality objectives. These deal with most measurable water quality parameters: some are fairly complicated, and there is no need to dwell on them here. Overall, the objectives allow for little change from natural background water quality.

D. Bay-Delta Report, Phase I Adopted

The Interim Plan concludes that ultimate protection will be best afforded by source control of non-degradable deleterious materials, reclamation of reclaimable portions, and relocation of non-reclaimable portions to areas of lesser environmental impact. Since this is not presently possible, it is stated, the most effective interim means will be a combination of improved treatment and relocation of discharges. Therefore, the Regional Board supports the general concept of Phase I of the Bay-Delta Report. This support is based on the following factors: 1) damage from wastes has already occurred in the north and south ends of the Bay; 2) the precise nature of toxicants and biostimulants are unknown; 3) feasible removable processes are unavailable; and 4) relocation toward deeper waters would provide the best assurance for meeting the objectives.

E. Bay-Delta Report, Phases II and III Rejected

It is important to stress, however, that the Regional Board does not support Phases II and III; rather, it strongly supports plans involving maximum effort toward reclamation. Phase I is supported because it would alleviate the immediate problems at the ends of the Bay, so that more attention could be paid to a more long-range solution involving maximum reuse of wastewater. There are still opponents to Phase I, including Board member William Weber, who feels that this plan only moves the problem from one location to another. These opponents advocate a higher degree of treatment followed by reclamation of the wastes. The majority of the Board has concluded that Phase I will allow for planning and construction of higher treatment facilities by 1975 in most parts of the Bay.

A timetable for funding and construction of the proposed facilities is currently being worked out. The limiting factor is money. The Clean Water Board Law of 1970 (Water Code, Division 7, Chapter 13) provides $250 million for the next 5 years as the State share of the costs. This share, if all requirements are met, is 25% of the total cost. The federal share can be as much as 55%, with the local interests supplying the remaining 20%. So a maximum of $1 billion is available for construction of water quality facilities.

F. State Timetable

The State Water Resources Control Board has recently adopted regulations (April, 1971) for administering joint federal-state grant programs. Funds are available only for those projects that are a part of Basin plans. During May, 1971, the nine Regional Water Quality Control Board conducted hearings on proposed projects, and each Regional Board recommended a list of projects to the State Board. A total of 329 projects were recommended, with a total estimated cost of $440 million. Of these projects, 241 were selected for grants during fiscal years 1971-72 and 1972-73 (Group 1 Project List), representing a cost of $331.6 million. This list was subdivided into 196 projects that may be funded during fiscal year 1971-72 for $261.3 million without prorating available federal funds, the remaining 46 projects totaling $70 million deferred until 1972-73. The San Francisco Bay region contains 26 projects recommended for grants during fiscal year 1971-72, totaling $90.9 million, while 14 projects at $20.9 were deferred until 1972-73. (Copies

of this list are available from the Regional Water Quality Control Board.) Funds will be made available as subregional studies suggested by the Regional Board are completed, which should be around the end of 1971. There is, consequently, no strict timetable for the waste removal from the North and South Bays and the upgrading of waste treatment in the Bay Area. Nonetheless, Kerry Mulligan, head of the State Water Quality Control Board, has stated that the waters of the State will be clean within 10 years.

IV. State & Regional Board Relationship.

The State Water Quality Control Board consists of 5 full-time members appointed by the Governor. The 9 Regional Boards, consisting of 9 members each, retain some autonomy from the State Board; they are guided by legislation rather than directly by the parent board. Legislation in 1970 gave the Regional Boards real power for the first time. They are now able to request injunctions from the State Attorney General against wastewater dischargers violating water quality standards. This injunction can carry a $6000/day penalty, and a ban against additional sewer hookups. This latter action has become known as the "building ban," since construction of buildings without provisions for sewage disposal is infeasible.

Injunctions cannot be issued indiscriminately; each Regional Board must be "reasonable" in its judgment, since most water quality problems have developed over a period of years and cannot be resolved instantly. If steps toward a solution are not taken, however, the regional Board may ask the State Attorney General to issue a civil-monetary fine which may include a temporary or permanent injunction and penalty up to $6,000/day. The discharger can appeal to the State Board, who may reverse the Regional Board's decision. The final decision rests with the courts.

With respect to the Bay-Delta Plan, the San Francisco Regional Board has displayed its autonomy regarding the Bay-Delta Report. While the State Board has not rejected the Plan they funded, the Regional Board has clearly stated that the second and third phases of the Report are not considered workable. While the State Board does have the power to overrule this decision, the likelihood is very remote because public opinion in the Bay Area strongly supports the Regional Board.

To facilitate implementation of such comprehensive wastewater disposal plan, various suggestions for a regional administrative body have been put forth. This regional service agency would supplement the Regional Water Quality Control Board by providing overall planning and coordination, but would not assume the control functions of the Water Quality Board.

At the time of this writing the Assembly has approved AB 1057, a bill sponsored by John Knox, which proposes a 3-year study on the formation of a multiple-purpose regional agency. This study would be funded through a 4 cent increase on the property transfer tax, raising from $700,000 to $800,000. Also, the Assembly has approved a bill (AB 2867) to create a nine-county S.F. Bay Area Sewage Services Agency. This bill, also sponsored by Assemblyman Knox, would give the agency authority to review plans for upgrading sewage systems.

V. Conclusions

The initial Bay-Delta Report was a noble effort to provide a comprehensive plan for managing the growing volume of waste water puring out of the Bay Area. In a less sophisticated region it might have been hailed as a landmark. But here the people and civic leaders could see that Phase II merely moved the problem out of Bay waters into the Pacific Ocean. The thought of having the sewage of millions of people shunted through *one* major sewage outfall, originating in Redwood City, on the San Francisco Peninsula, and crossing the San Andreas Fault to the Pacific was almost begging for calamity. The key to biological survival has always been the maintenance of diversity and flexibility. In some regards, Phase II certainly lacked flexibility.

Additionally, the Bay Area public became aware that such a proposal could seriously affect the Pacific Coast and Monterey regions. In the Bay-Delta report, the Kaiser Engineers predicted that current flows would carry the discharges from the Redwood City plant out to sea. This was based on very minimal data. Present information indicates that this may not be the case at all. The effluent might merely move southward along the Pacific Coast. Monterey Bay has been in the process of trying to solve its own pollution problems and does not need this added load. As we shall see in the next chapter, opposition to the Bay-Delta plan came on rapidly.

The San Francisco Regional Water Quality Control Board supports Phase I of the Bay-Delta Program. While they have not categorically rejected Phases II and III, they do not support these. The State Board has ultimate authority to reject or approve these three Phases. To date they have not indicated a position pro or con, but members of the Regional Board believe that these latter two Phases will indeed be rejected, both because of their own opposition as well as public sentiment against them. While Phases II and III may be passing into history, to be replaced by the *Interim Plan* and its successors, the fact that the impact of so much waste water on the receiving area was so minimally investigated is significant. With a view toward avoiding this type of error again, we present the material in the next chapter.

Chapter Seven

MONTEREY LOOKS AT THE BAY-DELTA PROGRAM

As a prelude to examining Monterey Bay's reaction to the Bay-Delta program we should set the stage, for the reaction there to this proposal was a function not only of their general environmental consciousness but also a reflection of our general ignorance regarding the impact of waste water in the marine environment. Many people have heard of the purported "death of Lake Erie" and think that surely we must know all there is to know about the effects of man's wastes on water systems. Lake Erie, however, is a *fresh water* system. As such, within its waters dwell completely different fish, phytoplankton, algae, and zooplankton. Meteorologic variables have a totally different impact; current patterns are different; the capacity to absorb biodegradable wastes is not the same. In short, a lake and an ocean *are* as vastly different as one might expect. While the effects of man's wastes, particularly urban, on fresh water systems are reasonably well known, they are largely unknown for the marine environment and the oceans of the world.

I. Prologue

Marine sewage pollution is inextricably tied with the problem of providing and salvaging clean water. Since there is now an increasing rate of water use per person and a growing population, the problem can only worsen. The practical solution is to recycle the same water, but recycling can be accomplished only through improved sewage treatment facilities for both coastal and inland regions. All sewage is potentially a reusable fresh water source, but once it enters marine receiving waters this potential is lost since desalination processes are far more expensive than reclamation methods. Despite the considerable research carried out on fresh water pollution and the types of treatment that best minimize it, the degradation of our inland fresh water systems persists. Now the oceans, which had seemed inexhaustible waste water receptacles, are threatened. Until recently, the marine realm had been considered an open ecological system into which all waste could be dumped without lasting harm. This idea was based upon the principle that dilution and biodegradation were better and cheaper processes than the use of artificial decomposition, as is employed in

secondary and tertiary treatment plants. Even though the physical and biological elements of the marine environment are powerful agents of decomposition, bodies of water near land *especially bays and estuaries*, can be overcome by a massive influx of waste.

Coastal communities are now 10-20 years behind inland communities in sewage treatment innovation, and most of the treatment systems now used rely on fresh water as a receiving body. This fact is tragic when we consider that the process of advanced secondary treatment with all its facets was available as early as 1952, when most of the present southern Monterey Bay treatment plants were being built (1). As of 1969, only Fort Ord had secondary treatment. Today, Monterey and Marina have operating secondary plants, and Carmel and Pacific Grove are in the process of constructing such plants. Santa Cruz county has *primary* facilities only and *none* of its four plants plans to advance to secondary treatment. An associated problem is that the western continental shelf is only one mile wide. The waters above this shelf simply do not have much mass movement and so they do not intermingle with the deeper ocean water. Despite this, the outfalls in the area dump waste within this one-mile limit, therefore virtually assuring that the sewage will not be diluted and dispersed. The problem is compounded when we realize that 90% of all edible marine life lives in this strip; continuous degradation of their environment results in a net loss in the food supply.

Few places in the world have attempted to protect public health through engineering methods to the extend found in the United States. Over the years, many advances have been made in waste water management. However, there has been an obvious gap between the knowledge and the application of the knowledge in the cities of America. Unless we begin to face the reality that our waterways are rapidly being polluted we face the dangerous situation of one day having this precious resource contaminated beyond our ability to repair it.

Strict enforcement of present laws must take place; new laws to cover industrial pollution must be passed and effectively used. And the communities cited in our study, as well as all others, must realize that their own health and safety rest on spending public monies to refine or dedesign their current sewage disposal systems.

In California, the former Federal Water Pollution Control Administration of the Department of the Interior (now the Water Quality Office of the Environmental Protection Agency) and the California Regional Water Quality Control Boards have attempted to encourage and to force compliance with legal standards of pollution control. In particular, governmental actions have shown concern for enforcement of pollution standards in oceanic dumping. Monterey Bay, additionally, has been the site of recent examination into the little researched effects of waste water disposal in the marine environment.

II. Guardian Angels of Monterey Bay

Jurisdiction over water quality standards of interestate and navigable waters rests with the Federal Government. Therefore, Monterey Bay is legally under federal regulation. Because the federal government does not exercise its roughly parallel powers the burden of creating and enforcing regulations remains primarily with the State.

A. Federal

Government jurisdiction over water quality is held by the Water Quality Office (WQO) of the newly formed Environmental Protection Agency. The FWQO has been in existence formally only since December 1, 1970, and is actually only the old Federal Water Pollution Control Administration of the Department of the Interior under a new name.

The Federal Water Quality Office has nine regional divisions throughout the United States. Monterey Bay falls in the Southwest Region, which has its local offices in San Francisco and Oakland. The responsibilities of the FWQO are spelled out in the Federal Water Pollution Control Act of 1956 and cover four areas:

1) Comprehensive programs for water pollution control

2) Water pollution control, research and development

3) Construction grants for treatment plants

4) Enforcement of water quality laws and standards

A closer look at the actual workings of the agency reveals a formidable gap between legal mandate and actuality:

1) Under the 1956 law, the Federal WQO is charged with promoting the development of regional planning for water pollution control. In reality, the regional office does no planning of its own, for the initiative for creating comprehensive programs remains with the state. The WQO does have a fund of $2.5 million to provide financial assistance to state and local agencies for the purpose of regional planning, but the amount is so small as to be of little value in stimulating area-wide studies of water pollution (2).

2) In order to increase knowledge of the nature of pollution and methods of controlling it, the WQO is authorized to gather information, conduct research, institute field laboratories, and provide grants for research and for demonstration units. In fact, the WQO does little research of its own, preferring to contract out and pay large sums to others for this purpose. To these ends, in previous years, Congress has appropriated $45 million annually for research and development; however, the fiscal 1971 budget was lower than last year's. By December, 1970, all the funds were committed (3).

3) To help municipalities cover the costs of sewage treatment plants, the FWQO distributes construction grants, covering from 30 to 40 percent of the total costs of construction. The city or district is expected to pay the remainder. Under special situations, more money may be available.

4) Finally, the FWQO retains authority to enforce water quality standards through litigation and fines. Because as long as 14 months may elapse between the citation and a legal suit, there are resulting serious deficiencies in their power to eliminate a pollution problem quickly.

B. State Regulation

The State Water Resources Control Board (set up by Stats. 1967, Chap. 284) has overall authority over Monterey Bay, out to the three-mile limit. The State Board, under powers given in the Porter-Cologne Water Quality Control Act (Stats. 1969, Ch. 482), formulates state policy for water quality control,

administers research programs, investigates pollution by state agencies, represents the state in federal activities, and directs several regional planning projects. In addition, the state board supervises the actions of the nine Regional Water Quality Control Boards.

In contrast to the limited federal activities, the state and regional authorities exercise considerable control. The California Regional Water Quality Control Board, Central Coast Region, is directly responsible for Monterey Bay. Santa Cruz, San Benito, Monterey, San Luis Obispo, and Santa Barbara come under the same jurisdiction. The board is empowered to (4):

a) Devise a regional water quality control plan

b) Prescribe requirements for all discharge

c) Require all persons or local agencies which discharge waste into Monterey Bay to file reports describing the nature of the discharge

d) Inspect facilities involved with waste discharges

e) Call for legal action to stop environmental damage

Several alternatives are available to the Board to stop present pollution and to prevent future pollution. In cases of emergency, or when a report which describes a waste discharge has not been filed, the Regional Board can request that the State Attorney General obtain a temporary restraining order, a temporary injunction, or permanent injunction enjoining a person or community from polluting. Suspect or potential polluters may also be required to submit a time schedule of actions to be taken which will prevent violations of water quality standards.

If the standards are already being violated, the Regional Board, after notice and hearing, may impose a cease and desist order to force violators to comply immediately; to comply according to a time schedule; or to take appropriate remedial or preventive action. If a cease and desist order is not complied with, the Board may instruct the Attorney General to petition the Superior Court to issue a temporary or permanent injunction forcing compliance with the order. If pollution still continues, the Regional Board may direct the Attorney General to begin procedures for fining the polluters up to $6,000 per day for each day that the injunction is not followed.

All the actions of the Regional Boards are subject to review by the State Board and the courts.

C. Local Control

Despite strong controls which the state and regional officials exercise, local control over pollution is rather limited. This situation renders those officials most visible and most affected virtually powerless to *prevent* serious pollution problem. Only when pollution has advanced to the point where public health is endangered may the county or some other local agency take court action through local nuisance ordinances.

If coliform bacteria counts (the standard used by most communities) exceed state standards, the county health officer at his own discretion may close, post or restrict the use of any public beach (California Administrative Code, Title 17, section 7950). Indirectly, the county and city may limit pollu-

tion through zoning laws, outlawing septic tanks and so forth.

Finally, some power does reside with individual citizens who can force pollution abatement. At least three procedures are open to them. First, a letter-writing campaign may be launched to find out what action is being taken against polluters. If no legal action is taken, then a petition may be presented to the regulatory agencies involved demanding restrictions. Finally, if this step does not evoke a response, the appropriate court may be petitioned for a *writ of mandamus* to force the agencies to exercise their statutory powers.

D. Association of Monterey Bay Area Governments (AMBAG)

Municipalities surrounding Monterey Bay created AMBAG in 1968 as a regional planning agency to conduct a comprehensive two-year study of water management and waste control for the Monterey Bay watershed. Included in the Association are representatives from Monterey, Santa Cruz, and San Benito Counties and representatives from most of the incorporated cities in those counties. Consulting and technical evaluation committees assist the AMBAG staff in the study.

The proposed budget for the study is $1.13 million; of which 50 percent (565,000) is to be provided by the Federal Government, under its Basin Grants program. $320,000 will come from the State, and $245,000 from AMBAG members.

To date, $130,000 has been appropriated by the State Legislature for the study. A local 1 cent tax is being considered for each of the three counties for the next two years to raise their share of the costs. Thus, a taxpayer with property valued at $25,000 will pay about 55 cents per year (5). Monterey County probably will shoulder 63 percent of the local burden, Santa Cruz County 31 percent, and Sen Benito County 6 percent. The Federal Government may provide only $434,200 for the study, rather than the proposed $565,000. Consequently, the state and local shares of the cost may be altered.

The consulting firm of Yoder-Trotter-Orlob & Associates of Walnut Creek has been selected for the study and preliminary work is already under way.

E. The **Central Coast Regional Water Quality Control Board**

In sum, it is fortunate that the Central Coast Regional Water Quality Board has jurisdiction over all the present polluters of Monterey Bay, for the federal government would be incapable of swiftly halting violators of water quality standards. The Regional Board has the legal power to deal quickly and effectively with any infractions within its boundaries.

The question which concerns us is what shall be the basis of actions taken by the board? Relying solely on the coliform bacteria count is not adequate, because it is an imprecise and inconsistent indicator of pollution. Research must still be done to provide better standards. The greatest danger to this area is that pollution will continue in the Bay for years before the ugly effects surface and become visible to the political eye. By then the damage will be so great that many more years will pass before the ecological system can recover.

III. Pollution and the Monterey Bay Ecosystem

Monterey Bay is a complex system of many interdependent organisms. The ecosystem can be likened to a pyramid: at the base there are the millions of microscopic plants; at the next level are the microscopic animals which feed on the plants; then there are larger animals which feed on the smaller animals. This creates a hierarchy of dependency, with larger predators dependent upon lower organisms for food sources. This system is more similar to a food *web* than a food chain, for at any level of the pyramid there are many different species that support the organisms higher up in the pyramid. Thus, if one species were to die off, another would be ready to occupy its place. The key to a healthy, stable ecosystem is *species diversity and complexity.*

The introduction of a stress into the environment will result in a decrease in species diversity. Those organisms which for some reason are better able to withstand the stress will out-compete the other organisms having a similar life style. Hence, a level of the pyramid could become occupied by a few species, or possibly only one. The introduction of still another new stress could then result in a drastic decline in the population of this species. Then all the organisms higher up in the pyramid would also die off, since there would be no other species to provide an alternative food source.

A. How Severe Is the Pollution?

It is impossible to state categorically just how stable the ecological pyramid of Monterey Bay is; there is not enough known about the population and distribution of the organisms in such a large area, nor are the inter-relationships between organisms adequately understood. Evidence now reveals, however, that the situation is much more precarious than was earlier thought. Studies were made in 1924 (6) and 1948 (7) of benthic organisms (animals living on the ocean floor) in Monterey Bay. A recent 18-month survey by the Hopkins Marine Station and the U.S. Naval Postgraduate School revealed that alarming changes had taken place since these earlier studies. In 1948, 192 species were uncovered; the recent survey, using a different and better methodology, showed only 39, a drop of nearly 80 percent (8). The 1924 study encountered 18 species of brittle starfish; now only 5 are found. In 1924, one of the species of brittle starfish was so prolific that it was clogging nets and becoming a nuisance. In the recent study, only 3 specimens were found. (It is possible that taxonomic changes since 1949 might have influenced these initial results; the study is still in progress.)

Hence, the indications are that the ecosystem is more fragile and susceptible to catastrophe than had been thought. Studies along the southern California coast carried out by the Alan Hancock Foundation, and along the San Mateo County coast, carried out by the California Department of Fish and Game, indicate that this alarming situation exists throughout a significant stretch of the California coastline; it is not just a local manifestation. The lack of species diversity probably has been caused by a number of substances invading the aquatic habitat: pesticides, oil, excessive heat from power plants, toxic chemicals, heavy metals, and obviously sewage. *Any amount of sewage of lesser quality than that treated by a tertiary plant will worsen an already bad situation, even if it is discharged a mile from the coast.* Hoping that sewage

will disperse into the ocean is like hoping Los Angeles smog will disperse into the heavens, never to plague mankind again.

The potential harmful effects on human health are dramatically pointed out by studies showing that sewage effluent discharged into the Bay or off Point Pinos may not disperse into the high seas, but rather return to the Bay. Studies of surface currents by the Hopkins Marine Station and the Moss Landing Marine Laboratories indicate that the effluent will be swept back into Monterey Bay with little chance of escaping: "It appears that much of the water in the Point Pinos area is transported back into the Bay in close contact with shore areas between Lover's Point and the Ford Ord beaches. Here there is little chance for oceanic mixing and maximum opportunity for the accumulation of both toxic materials and oxidizable organic matter and nutrients." (9)

Remaining in the Bay, the effluent is concentrated and its capability for disrupting the marine environment is heightened. A report prepared by the Hopkins Marine Station stated, "In several cases the phytoplankton blooms involved organisms which contain toxins, which in turn cause fish kills and the destruction of marine life in the Bay. The accumulation of oxidizable material and nutrients can occur even in oceanic areas where the current systems tend to funnel these products into restricted areas or in situations where there is little circulation and dilution of these products. Monterey Bay is just such an area." (10)

B. Summary

At present, the condition of the marine ecosystem is fragile. New stresses are being placed upon it by other forms of pollution, which in their total effect cause serious deterioration of the marine environment. Consequently, the discharge of primary or secondary effluent into Monterey Bay or even the deep ocean is unacceptable as a long-term solution. In addition, since sewage may often be *returned* to the beaches rather than dispersed into the ocean, the health and safety of the human population in the Monterey Bay region is threatened by this naive and short-sighted method of sewage disposal.

IV. Pollution Load in Monterey Bay

Monterey Bay has become the figurative toilet for much of central California. The Western continental shelf is less than one mile wide (relatively narrow when compared to the Eastern shelf), but still most local outfalls are within its limits. The waters above this shelf undergo little mass movement, and very often have unpredictable and complicated directional changes. Numerous waste materials are dumped into the Bay each day; domestic sewage is only one component. Other contaminants are also debilitating:

1) "Hard" chemicals entering the Bay from the Carmel, Salinas and San Lorenzo Rivers and the Elkhorn Slough;

2) Contaminants entering from the air, predominant in the Davenport areas, and the prevailing air currents from the San Francisco Bay region;

3) Human waste and other materials piped straight into the water at marinas and from boats.

Attempts have been made through legislation to regulate the waste of marina restaurants, but the laws are largely ignored. The federal government has recently begun a mandatory program requiring all boats to have self-contained waste disposal units; and

4) Oil slicks caused by tankers and drilling. Private research executed for Humble Oil and Refining Company, and concealed from the public, found Monterey Bay to be rich in oil deposits. Before Humble could take action on this information, oil drilling and oil tankers were outlawed in the Bay by last-minute legislation. However, the restricted area extends only three miles beyond the outer continental shelf. Santa Barbara Bay has had similar restrictions, but still has been ruined by offshore drilling *beyond* the limits set by law.

Many groups have intensified and redirected their sewage pollution studies. In the Monterey Bay region prominent groups are:

1) the Monterey County Health Department

2) the Santa Cruz County Health Department

3) the California State Health Department

4) the Central Coast Regional Water Quality Control Board (WQCB)

5) the California State Department of Fish and Game

6) Hopkins Marine Station of Stanford University

7) the Moss Landing Marine Laboratories (affiliated with the California State College system).

Some public agencies have changed their official stance because of public concern, although too often – as in Seaside, Pacific Grove and Carmel – a public nuisance has been created before concrete action is taken.

A. Beach Safety

Monterey Bay is widely used as a recreational center for northern Californians. Each summer thousands of people flock to its beaches. An important question must therefore be confronted: does the water in the Bay present a health hazard to the occasional user? This question ought to be resolved easily by using standard bacteriological sampling procedures. However, the opposite proves to be the case.

1. The Coliform Controversy

Coliforms are a bacterial group that grow in the intestines of man, and are excreted in feces. They are readily detected and enumerated in sewage by multiple fermentation tube techniques, and have served as the traditional indicator of fecal pollution. Coliforms are not usually dangerous pathogenic bacteria, though they do cause infections in the gastrointenstinal and urinary tracts. The value of coliforms, therefore, is in the correlation which exists between their presence and the presence of more harmful enteric bacteria.

Though coliform numbers have been used as the criteria for improvements in plant operation, they are in no way an indicator of total pollution levels. The validity of the coliform test lies in its help in determining sites that *might* be hazardous to human health. High bacterial counts may be a cause for

treatment plant reappraisal, but the type of action to be instituted at a beach can only be determined by a detailed biological and chemical study.

The agency which enforces and regulates water quality standards for Monterey Bay, the Central Coast Regional Water Quality Control Board, follows the water quality standard set by the State Public Health Department:

> Samples of water from each sampling station at a public beach or public water-contact sports area shall have a most probably number (MPN) of coliform organisms less than 1,000 per 100 ml.; provided that not more than 20 percent of the samples at any sampling station, in any 30-day period, exceed 1,000 per 100 ml., and provided further that no single sample when verified by a repeat sample taken within 48 hours shall exceed 10,000 per 100 ml (11).

This test counts bacteria of the entire coliform group and does not differentiate between species (i.e., *E. coli, Aeobacter aerogenes, Salmonella typhosa*, etc.).

The validity of the coliform test is suspect for the following additional reasons: 1) values can vary greatly on different days though effluent composition has not changed and environmental conditions seem similar; 2) physical factors – water turbulence, ultra-violet rays, phytoplankton predation upon bacteria, and tides – may cause radical changes in coliform numbers; 3) during the winter and spring periods coliform counts are always low due to unexplainable parameters (this case is illustrated by the ridiculously low readings recording during the winter-spring period for the raw sewage being discharged in Stillwater Cove of Pebble Beach); 4) deviation in the numbers of coliform counted (determined by a probability table) can be as much as 400% (12).

Under the new Porter-Cologne Act, litigation brought against treatment plants would be based, in all likelihood, upon the coliform count; and so, until further evidence is found such legal action might be at a disadvantage in the courts.

Correlation between coliform counts and disease incidence in humans is weak at best. There is simply a lack of epidemiological evidence to substantiate the conclusion that disease is spread from bathing beaches known to have high coliform counts. The First International Conference on Waste Disposal in the Marine Environment supported this view by asserting:

> The coliform index, as presently employed, does not appear to be a realistic measure of the hazard from enteric disease nor the aesthetic qualities of saline bathing beaches (13).

Water quality standards for recreational use around the nation vary from as low as 240 MPN/100ml (New York City) (14). This variation occurs because standards are not *federally* controlled; counties are free to make a value judgment upon the risk of contamination based on probability studies.

While the coliform test is plagued with statistical and sampling difficulties which cause its validity to be in question, it remains the only feasible indicator available for public health determination of enteric

pollution. We have no other simple microbiological test for contamination of water from fecal matter – i.e., material from mammalian intestinal systems. Essentially the test tells us that *something* is there, but does not tell us exactly what.

The bacterium, *E. coli*, is found in virtually all excrement from a normally functioning intestinal system and generally will not be found in large quantities from any other source. Therefore if *E. coli* is quantitatively cultured from a water source, and if the bacteria count is higher than would occur by chance alone, the obvious conclusion is that fecal matter has contaminated the water. Since *E. coli* does not normally pose public health problems, its presence *alone* might be insignificant. However, numerous known pathogenic organisms are transmitted through fecal contamination of water. Two such bacteria are *Salmonella* (which is responsible for typhoid fever) and *Shigella* (which causes one type of gastroenteritis, with accompanying severe vomiting and diarrhea). Another is the hepatitis virus.

A high *E. coli* count from the coliform test warns of the high probability that there are *less readily detectable, pathogenic organisms* present in the water. Therefore, water in which a high coliform count is found should be viewed as unsafe for direct human consumptionor contact.

The next question to be anticipated is why other pathogens cannot be isolated from the water sample. The reason is that a far lower incidence of typhoid, bacterial gastroenteritis, or hepatitis is found in this country than in other countries, or than was found here only 60 years ago. Since the incidence rate is low, there are not many people in the population who *could* spread the disease by contaminating the water systems through passage of pathogenic organisms out of their intestines into the water. The result is that when sewage is inadequately treated, usually *E. coli* will be the only micro-organism which can be isolated. A pathogen from the infrequent disease carrier, however, *also* might be there, but only once out of a thousand times. Since we do not know which one time that will be, we call any of the 100 tests which *do* show definite *E. coli* contamination "positive" for pathogenic material. After all, when considering public health and safety, it is generally wiser to err by calling water unsafe too often than to miss the one time in a thousand when *S. typhosa* is present and strikes a thousand unsuspecting people.

2. Bacteriological Analysis and Reaction

In April, 1969, under the auspices of the Monterey County, Santa Cruz County, and California State Health Departments (with 11 other agencies participating), a coliform study was made of the nine sewage treatment plants in Carmel and Monterey Bay. Six months later, because the samples studied seemed to indicate a serious health hazard, a public announcement was made. The results were alarming: coliform values which exceeded the *maximum* standards set by the state were found in Santa Cruz, Seaside, Monterey, Pacific Grove and Carmel.

Number of Samples*

MPN Above 1000/100 ml by Discharger
April – September 1969

Discharger	%
(North to South)	
City of Santa Cruz	31%
Moss Landing Harbor	35%
Ford Ord	17%
Seaside Sanitary Dist.	51%
City of Monterey	58%
City of Pacific Grove	34%
Carmel Sanitary Dist.	39%
City of Salinas	11%

*Report by the Monterey Bay Bacteriological Study Group

B. Official Reaction

The Monterey County Health Department took immediate precautionary steps to close beaches in Carmel, Pacific Grove, and Seaside. The Water Quality Control Board followed in December by issuing cease and desist orders to Pacific Grove, Seaside, and Carmel. Monterey was spared, because plans for secondary treatment had already been made public.

The sanitary departments were running scared:

1) In Carmel, heavy chlorination was started in January of 1970. Plant operations officials tried mainly to divert blame for some of their pollution problems onto the Carmel River (approximately 1,000 feet to the north) and the San Jose Creek (on Monastery Beach – 3,000 feet to the south). It was true that coliform counts had been very high in the estuarine regions of both areas, but neither stream flowed in the summertime, the period for which the highest counts in Carmel Bay had been recorded and during which time milk-of-magnesia-colored water sometimes extended 1,000 to 2,000 feet south of the outfall.

2) In Pacific Grove during the summer of 1969, coliform counts were found as high as 7.2×10^7 col/cc near the outfall pipe. In order to combat the high bacterial counts heavy chlorination was instituted; residual chlorine readings were later recorded around the outfall at 50 ppm. (Research at Hopkins Marine Station has since obtained data that suggest pollution caused by chlorine may be even worse than that of untreated sewage (15).)

In the case of Pacific Grove, the bacteriological study uncovered another interesting item: coliform sampling procedures had been performed inadequately for years by the plant (16). If the operators had reported high values their jobs would have been endangered; accordingly, most samples were purposely taken from visibly unpolluted spots which the effluent by-passed. The question arose: How many other

plant operators had chosen "convenient" sampling areas?

3) In Seaside, heavy chlorination was instituted to kill the bacteria, but nothing was done to improve existing treatment plant inadequacies.

4) In Santa Cruz, conditions had probably been worse, because high chlorination levels were detected during the periods of inspection by outside agencies. The chlorination process was suspect. Was the chlorination initiated only one or two days before the designated sampling period? (A later evaluation in September of 1970 indicated that chlorine dosages were satisfactory (17).) From the outside, the treatment plant looked well-kept and efficiently operated. A generator was on hand in case of an emergency, and all the equipment was available for full primary treatment. How could such apparently good treatment facilities have produced such high fecal pollution? Upon closer inspection, the digesters and centrifuge were found to be overloaded, causing a short retention time for cycling influent. This sewage therefore was being released after only superficial treatment (18).

The solution reached by all plant operators to counteract the coliform values was essentially the same: chlorinate heavily and "kill" the problem. But chlorination could only treat the symptom and not the cause – out-dated and inefficient treatment facilities. The WQCB issued building bans to Pacific Grove, Carmel, Seaside and Fort Ord in February. Fort Ord was included in the building ban (and also the cease and desist orders) because their outfall was located above the intertidal level and clearly was polluting the beach. Around the same time, because coliform counts had dropped, the beaches were re-opened by the Monterey County Health Department.

C. Health Impact

In East Cliff, an unforeseen problem had arisen from the fact that the outfall's field of dispersion had become a popular surfing area. Nine cases of hepatitis had been reported over a two-year period, plus numerous cases of gastrointestinal disorders. Whether these diseases had come about because of inefficient plant operations was debatable. On the one hand, the field of dispersion should have been expected to be highly contaminated. Plant supporters claimed, however, that high coliform counts would have been found in this area *regardless* of whether the treatment had been advanced primary (which they claimed to be using) or full secondary treatment (19). This statement appears to have been only partially correct. They failed to mention that when compared to primary treatment, secondary treatment drastically reduces the numbers of coliform bacteria. Even though the counts would have been relatively high (although below the 1,000 MPN/100ml), the danger from pathogenic bacteria would have been cut enormously, and the probability of contracting disease should have been correspondingly less. Recently, the Regional WQCB issued the county a warning: unless East Cliff is combined with Santa Clara, court injunctions and a suit against both the county and the city of Capitola may follow.

D. Taking Action

Monterey County Health Director, Dr. Richard Fraser, showed his concern for the public's safety by

immediately posting those beaches that seemed to present a health hazard. However, the attitude of the Santa Cruz County Health Department was somewhat different. At the Advisory Board Meeting of the Bi-county bacteriological study, coliform values were reported as a mean over a larger period of time. Since great fluctuations in counts usually occur with extended time, this procedure was inappropriate and misleading. Representatives of the County Health Director said they intended to wait and see what the results of the bacteriological study would be after one year before posting any beaches. A further example of political escapism occurred when the mouth of the San Lorenzo River (a highly polluted area) was *not* posted, for the reason that the pollution in the river was caused by communities outside Santa Cruz county! Finally, in July, 1971, the Rivermouth area was posted – nearly two years after pollution in the vicinity had been discovered. Even Pleasure Point (located off the East Cliff plant's field of dispersion near "Sewer Peak," as it is known by many surfers) had not been posted.

Even now, after months of study, no coastline in Santa Cruz county has been posted. Dr. Richard Svihus, Director of the Santa Cruz County Health Department, is quick to correctly point out that no absolute correlation has been drawn between high coliform counts and communicable disease rates. Our research has convinced us that the lack of such a correlation, however, comes merely from a *lack of* epidemiological data. Legally, as already mentioned, the Health Officer at his discretion may post and restrict swimming, but in Dr. Svihus' opinion, there is no direct threat to the public from sewage deposits.

We should note that under Dr. Svihus' direction epidemiological programs have recently been instituted, in the form of weekly checks of the causes of death in Santa Cruz City. Though there has been a definite rise in hepatitis within the county, Dr. Svihus claims that no correlation may be drawn to water pollution statistics. He checked the records of the Santa Clara County Healty Department, and found no rise in disease rate of surfers from the polluted area. Hepatitis deaths very possibly may be attributed to increased drug abuse.

Epidemiological studies require much time and are entirely beyond the scope of a small health department. Dr. Svihus is making a valiant effort, but full-time research is needed.

E. Effluent Current Patterns

In order to determine the best location for outfalls and to study the extent of sewage pollution for specific areas, the movement of effluent within the marine environment must be known. As we have stated, the western continental shelf is so narrow, and its waters undergo so little movement, that dilution is practically nonexistent.

1. Hopkins Marine Station Study

After preliminary studies, Hopkins Marine Station tentatively found that the currents of southern Monterey Bay and Carmel Bay were very changeable, but predominantly maintained an onshore direction and were within the inner parts of the Bay (See Fig. 7-1):

The basic pattern of water circulation in the south end of Monterey Bay is dominated by (1) the current system which brings water from the Pt. Pinos region into the Monterey Harbor area; (2) a current which runs east and north along the near shore areas of Monterey, Seaside and Fort Ord; and (3) a slow moving system with water moving seaward only near the center of the bay (20).

At Pacific Grove, not much dilution of effluent was found in the summer of 1969. Bacterial counts were higher than 11,000 MPN/cc even in areas over 1,200 feet from the outfall (21). Based on this evidence even if Pacific Grove had extended their outfall, as they had planned to do at one time. the only result would have been to shift contamination from the Point Pinos region to the beaches and offshore waters in the more populated areas immediately north.

The two bays could very well accumulate sewage contaminates to form large lakes, because relatively little mixing or dilution is occurring. Such a "dead lake" lies off New York City, as reported in the New York *Times* last year.

Within such a context as we have been discussing here, proposals for high density development of prime agricultural lands, such as that for the Odello acreage immediately south of Carmel, are totally absurd. Carmel's sewage treatment plant is already out of date, contributing its share to the degradation of Monterey Bay and the health hazards along the Bay's scenic beaches. Such high density development will grossly increase the pollution load produced by existing facilities and substantially negate the beneficial effects of proposed improvements.

No detailed current studies have been done on any part of the Bay and nothing definite can be said about the northern region in isolation, since it is completely separated from the southern part of the Bay by the Monterey Canyon.

F. The Sludge Disposal Problem

Disposal of solid organic wastes so that disease factors will be minimized is quite a problem for most present treatment plants around Monterey Bay. The City of Monterey is an exception; it utilizes an advanced multi-hearth incineration as part of the updated facility. This system, which operates at 1500°C. kills many pathogenic organisms (such as the tubercle bacillus) which would otherwise survive in activated sludge and would be coated with an impermeable gelationous layer. The viable sludge then emerges as a sterile dust which can be used safely for land-fill. Previously, the sanitation engineers flushed the sludge from the digester out into the Bay during the winter months, since flushing the digester tanks is necessary to keep them clean.

The operation of the incineration system at the *East Cliff* plant is a mystery. During the winter of 1970, operators claimed to have removed only two wheelbarrows full of ash a week from their incinerator (a converted digester) (22). In contrast, the Monterey plant, which services an area of about the same population as the East Cliff plant, removes approximately 450 pounds of ash a day! By this information we can only conclude that East Cliff does not remove its ash, but only the sand and grit base. Obviously, most of the ash enters the effluent. To make the situation worse, the incinerator is not always operable, and no

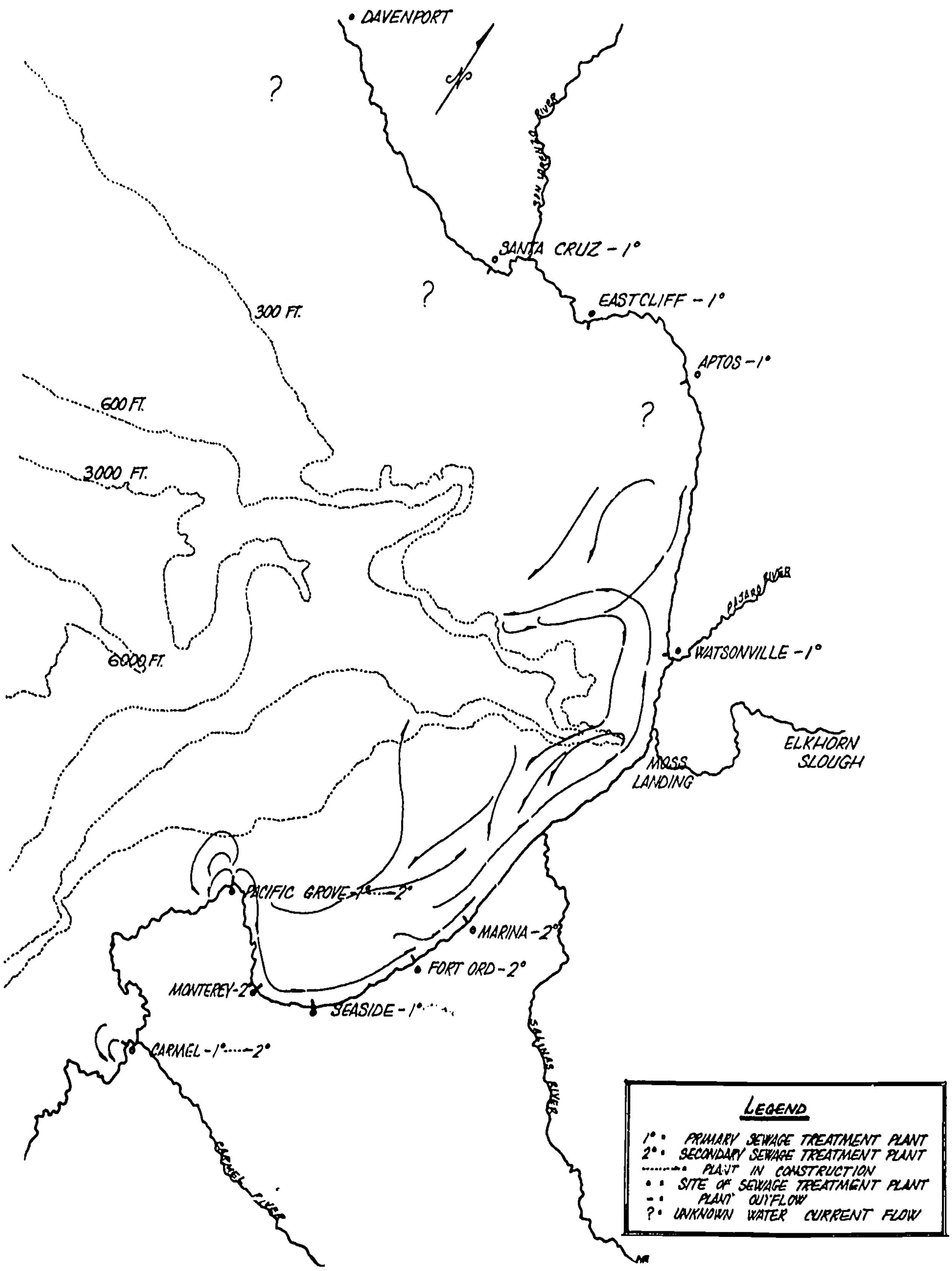
DAVENPORT
SAN LORENZO RIVER
SANTA CRUZ - 1°
EASTCLIFF - 1°
APTOS - 1°
300 FT.
600 FT.
3,000 FT.
6000 FT.
PAJARO RIVER
WATSONVILLE - 1°
ELKHORN SLOUGH
MOSS LANDING
PACIFIC GROVE-1°----2°
MARINA-2°
FORT ORD-2°
MONTEREY-2°
SEASIDE-1°
CARMEL-1°----2°
SALINAS RIVER
CARMEL RIVER
LEGEND
1° PRIMARY SEWAGE TREATMENT PLANT
2° SECONDARY SEWAGE TREATMENT PLANT
PLANT IN CONSTRUCTION
SITE OF SEWAGE TREATMENT PLANT
PLANT OUTFLOW
? UNKNOWN WATER CURRENT FLOW

Figure 7-1

back-up system is available. During one period in 1969, the incinerator was closed down for three months and the sludge simply flushed into the sea (23).

Pacific Grove has been faced with a different problem. Their digester has not worked effectively since 1957, when it was emptied and improperly seeded. The digester sludge was discharged periodically through the outfall pipe – because of cleaning difficulties – however, the discharge was essentially incubated, disease-laden organic material. Digestion is an unreliable process in any case, because the anaerobic bacteria used are sensitive to minor changes in their environment and are consequently unpredictable organisms. Decomposition of solids often depends upon a combination of factors: the nature of substances entering the chamber, pH, temperature, and degree of mixing. The WQCB put a halt to digester sludge discharge only last year, in June.

In *Santa Cruz*, much of the primary sludge has been used as fill by the Parks Department (24). When the Parks no longer needed or wanted the sludge, the treatment plant was overwhelmed and could not handle the input. As a result, in late 1969, 1400 gallons of sludge per day were flushed through the outfall pipe (25). Now the sludge is being trucked to the city dump.

The use of primarily treated sludge as fill is not a common practice and definitely presents a health threat to the public. The City of Milwaukee has sold secondary activated and vacuum filtered sludge under the brand name Melorganite. The material is rich in B-12 and minerals and is apparently safe. The contents and dangers of primary sludge have not been studied to the same extent as secondary sludge and it should *not* be used as either fertilizer or fill.

G. Waste Water From Other Sources

Contamination of the Bay waters should not be blamed solely on discharges from municipal treatment facilities. There are numerous other sources of pollution which contribute considerably; a few of the major ones are mentioned below:

1. P.G. & E. and Pollution

The P.G. & E. power plant at Moss Landing serves central California, and is the largest non-nuclear power plant in the United States. The second largest boiler in the world is on the site, generating huge amounts of water used to supply a steam source which in turn runs the turbines and cools the machinery used. Our concern is the thermal discharges generated by the plant. The temperature around the diffuser has been recorded at 17° higher than the ambient water. In the 1969 annual stockholders report, P.G. & E. stated that they had been able to develop and operate their thermal heating units so that they had *no* adverse effects on marine life. Despite this pronouncement little data has been available on this subject, and there is no way to confirm the company's statement. We must have confirmation, however, because land has already been purchased on which will be built still another plant, perhaps a nuclear power plant.

On April 9, 1970, P.G. & E. publicly announced that they were considering a site in Davenport, just north of Santa Cruz, for a $200 million nuclear power plant to supplement the Moss Landing plant. A P.G.

& E. spokesman admitted that temperatures in the water around the outlet could rise 20 degrees, but he continued to say that this increase would dissipate within 500 feet and would not harm marine life (26).

The second part of his statement should be taken as conjecture, since very few studies have been done on the effect of thermal increases on fish or plant vitality. Thermal pollution is a definite threat: "Hot water discharged into a bay, river or even the ocean can create biological deserts. A 3^{0} or 4^{0} difference in temperature can be critical . . .(27). In addition, the threat of radioactive poisoning also remains largely unexplored and potentially dangerous. Conservation groups have discovered that P.G. & E.'s nuclear power plant in Humbolt Bay has been discharging radioactivity into the surrounding water in excess of the proposed new Atomic Energy Commission ceiling, and is generally regarded as "the dirtiest of the nation's power reactors." (28) The effects of these discharges must be known as the number of plants and their capacities rise. The Davenport plant would have a capacity 110 times that of Humbolt (29).

2. **Kaiser Refactories**

Kaiser Refactories at Moss Landing produce temperature-resistant materials, and in the process release large quantities of magnesium and calcium into the Moro Cojo Slough which flows into the harbor district at Moss Landing. Coloration of the harbor waste waters often indicates the presence of these chemicals. The waters have been known to vary from milky white to an abnormal bright blue. The plant presently returns some 30 mgd of processed sea water.

Though no government agency has ordered a halt to this pollution, pressure has been placed on the company by the harbor district and the public. Plans have been made for a new outfall line to be installed in the near future. It will extend 400 to 600 feet into Monterey Bay and cost between \$500,000 and \$700,000. (This expenditure is part of approximately \$75 million that Kaiser Aluminum and Chemical Corp. plans to spend during the next eight years on environmental controls for their existing facilities(30).) The outfall will be terminated with a large diffuser unit 30 feet below the surface. The study for this outfall line was done by Moss Landing Marine Laboratories.

Manager William T. Burns, in support of the new outfall, has asserted that environmental quality could be maintained through appropriate dilution and dispersion. He also asserted that the processed seawater from such a device would have "no noticeable effect" on the marine ecology of the region (31). Both his first and second assertions can only be taken as opinion, since evidence has not been compiled to substantiate them.

An unfortunate associated problem is that the Moss Landing community is still using septic tanks as the major form of sewage disposal. Septic tanks are the *least* desirable form of sewage disposal. No pollution problem, in terms of coliform bacteria count, has yet been noted; but monitoring must continue in this area. These pollution problems must be solved soon, for a major new industrial harbor is now being planned, which promises still further pollution unless sewage facilities are upgraded.

3. **Negligent Slaughter Houses**

Many slaughter houses routinely discharge bloody waste materials directly into the ocean. In northern Santa Cruz, near Natural Bridges State Park, Walti-Schilling and Company discharges 75,000 gallons of raw sewage a day through trenches and out onto the beaches at low tide (32). Below the site of dispersion is an area of abundant biota and numerous delicate tide pools. Recently, it has come under the control of the University of California at Santa Cruz because of the interesting research data it offers. These fragile tide pools have been found "blood red" at certain times because of the contamination from the outfalls nearby. This scale of pollution may incite public pressure to force Walti-Schilling to attach its sewer facilities with those of Santa Cruz (33).

The Watsonville Dressed Beef Company discharges its waste products into an open air ditch. Raw sewage eventually flows into the Pajaro River and out into the shellfish reserve area. This river has been known to turn yellow at times, but Dressed Beef has refused to pay connection charges into the city sewer system and thereby has acted in a tragically irresponsible manner. The one exemplary company has been the Salz Tannery (a treatment operation, not slaughtering house). They have spent nearly $300,000 to build sewer connections with the City of Santa Cruz.

4. **San Lorenzo River Pollution**

The City of Santa Cruz is becoming increasingly concerned about pollution in the San Lorenzo River. The city derives a large portion of its drinking water from the river and the estuarine region is used heavily for recreation. Since the river is proximate to the main city beach, the prime tourist attraction in the area may be receiving the river's contaminates. Findings in early 1970 indicated that the coliform count at the mouth of the river exceeded Water Contact Sports Standards 40% of the time (34). However, no health hazard signs were posted until July, 1971.

Much of the pollution is due to municipal and rural waste, detergents, and oils that drain into the river from areas not in the jurisdiction of the City. These areas include the San Lorenzo Valley, Felton, and rural areas in the Santa Cruz mountains. The most advanced treatment used in these towns is the septic tank and even they are not common. Because the river in these areas has been found to contain significant numbers of coliform bacteria, the County Board of Supervisors have threatened a building ban action if attempts are not made to alleviate the problem. Felton and Ben Lomond, however, have not been forced to correct the difficulty. Nevertheless, business leaders there have ordered a feasibility study of a sewer system. Boulder Creek-Brookdale businesses now are beginning to support sewer research as they are aware that reclamation projects can receive up to 80% federal support. Yet, the overall situation still looks bleak; the attitude of most of the people in these areas is perhaps best expressed by a sign posted in a bar at Boulder Creek: "Flush the toilet; Santa Cruz needs the water." (35).

H. **Regional Approaches**

Regional government could solve these problems. Without such control, the pollution will continue to move from an area that has not shown much concern about the problem to an area that is practically

powerless to control the situation and could become economically jeopardized. Strong regional cooperation and organization seems an almost impossible task at the present time. Municipal rivalries over attracting tourists, the reluctance of many local leaders to give control to a bigger body, the fear that one area may be enhanced at the expense of another by such a body, and the fear by many citizens of "creeping centralization" and "socialism" have stymied a comprehensive regional sewage treatment program. Big money accompanies sewage treatment, and power accompanies big money. Some people are afraid that such power placed in a regional pollution agency would inevitably take hold in other areas and lead to the erosion of local control. What they fail to realize is that pollution must be dealt with in much the same manner as a disease is treated within the human body – the entire body must be thoroughly examined and the disease caught at its origin. As long as Monterey municipalities persist in dealing with the "extremities" the disease of pollution can only remain and grow. A unified course of action is desperately needed but will not be implemented until the people are educated enough to realize that regional control is by far the best course of action.

Conclusions

The Santa Cruz County Health Department must take action following the example of its counterpart in Monterey County. When high coliform counts are recorded, pressure should be applied by posting health hazard signs and making the pollution publicly known.

Each day more than 30 million gallons per day of domestic sewage are pumped into Monterey Bay. Sewage effluents within the next ten years could increase four-fold to as much as 120 mgd! Considering these facts, it is frightening to learn from recent current-flow studies that the northern and southern parts of the Bay may be very much like two lakes (divided by the submarine Monterey Canyon). With the addition of many chemical pollutants from rivers and factories, the Bay could soon become an enormous pool of pollution.

In the northern end of the Bay, many coastal sanitary engineers still will not accept the fact that the ocean – even though it holds 320 million cubic miles of water – is just as susceptible to pollution as a fresh water lake or stream. Even though the sea, because of the abundance of biota, can rapidly oxidize organic wastes, many bays (San Diego for example) have been so overwhelmed with material that their capacity to dilute has been entirely negated. On a larger scale, the greatest percentage of persistent waste materials drains into and then remains in the ocean itself. Since the ocean has a finite volume (just as our atmosphere has) contaminants will inevitably cause damage. Once such stress is blatantly visible, however, the major destruction will have occurred.

Environmental parameters are much more numerous and confusing in marine areas than in fresh water bodies. The study of sewage treatment systems in such areas is thereby made correspondingly more difficult. In Monterey Bay, oceanographic studies are being complicated further by marine outfall sewers with fields of dispersion which overlap. Most recognizable are those of Monterey, Seaside, and Fort Ord. Biologists have begun only recently to compile quantitative evidence to prove that domestic sewage is

harmful to marine biota. Until their studies are completed, suggestions for coastal treatment plant improvements will continue to be based solely upon engineering-oriented ideas rather than upon additional environmental considerations. Many fear that such marine studies have begun too late, for often the most dangerous effects are the long-term or chronic ones. There is the danger that preliminary research on these will not be compiled and understood before irrevocable damage to marine systems has occurred.

From this and other studies (36) we have been able to conclude that civic leaders in the Monterey Bay region regard their sewage systems as inadequate and in need of massive improvement. Questionnaire data (37) additionally showed that the Monterey Bay region had a generally knowledgeable, well-educated, and perceptive group of politicians and planners. They certainly are more conscious of the ramifications of their decisions than are most politicians in the State, and they genuinely attempt to adopt a more comprehensive approach toward growth concepts and environmental planning. The considerable majority of decisionmakers realize that there is a pollution problem in the Bay which requires action. Three-fourths of them thought that the Monterey Bay region should have a regionally planned sewage treatment system, for the task at hand requires a more comprehensive attack than can be provided by each city working in isolation from its neighbor. They also feel that in the near future the region will have to adopt tertiary treatment with water reclamation.

Within this context of a region which is striving hard to correct its own problems, it might be interesting to review how they reacted to the news that they might well be receiving the wastes from the San Francisco Bay Region, through Pase II of the Bay-Delta Program.

V. Monterey Bay Area and the Bay-Delta Program

Confrontation over the San Francisco Bay-Delta Water Quality Control Program was not the first time the people of the Monterey Bay region had locked antlers with their northern neighbors. In 1965, the California Department of Water Resources (DWR) released *Bulletin No. 127* on the San Joaquin Master Drain, which proposed to dump Central Valley agricultural wastes into Monterey Bay. The Valley's agricultural wastewaters (480 mgd by 2020) would be diverted to the Pacific Ocean by way of closed conduits that would run north from Mendota, westward across the Santa Clara Valley to the Pajaro River, and from there into Monterey Bay and the deep waters of the Bay's underwater canyon (38).

The idea that 480 million gallons of pesticide-contaminated agricultural wastes would be pouring into their Bay each day horrified the officials of Monterey and provided the impetus in the following year for the formation of the Association of Monterey Bay Area Governments (AMBAG), a voluntary organization of cities and counties around the bay. AMBAG's organizers knew that concerted effort could give more power to their protest; they were also convinced that the Monterey Bay communities could not solve their own water quality problems without a regional approach.

A. Initial Response

The Monterey alternative was mentioned again in 1969 in the San Francisco Bay-Delta Water Quality

Control Program, along with a new alternative – a combined ocean-Antioch design. The latter plan proposed that 330 mgd of the agricultural wastes be released into the ocean at Monterey Bay, while 150 mgd be eliminated at Antioch, which is the designated outlet in the main Master Drain Plan. However, in an interview in November 1970, Raymond Walsh, director of the Bay-Delta program, stated firmly that Antioch had been selected as the discharge site, and seemed to imply that the Monterey alternative was no longer a possibility (39). Monterey Bay area people, including Monterey City Manager John Nail, are not entirely convinced and are keeping careful watch for any change of plans. Nevertheless, the initial menace of an agricultural drain was overshadowed by another proposal of the Bay-Delta program, which would have posed an even greater threat to the Monterey Bay area – the Phase II plans.

According to Nail, it was in 1966 that AMBAG first heard of San Francisco Bay-Delta attempts at a comprehensive wastewater management program. When it became apparent in 1967 that the discharge of a large quantity of sewage into ocean waters a few miles north of Monterey was being contemplated, AMBAG became concerned. At no point had they been consulted about such a proposal. Therefore, in September 1968, the Association invited Raymond Walsh to explain and clarify the plans. Walsh reportedly attempted to reassure the Association members that no harm would come to Monterey and that intensive research would be conducted before any of the plans were implemented.

On March 17, 1969, a press release in Oakland publicly unveiled the program, and shortly thereafter, in April and May, public hearings were held in San Jose, Martinez, Sacramento, and San Francisco. At the San Francisco hearings, delegates from various groups in Monterey, including the Citizens for Clean Environment, the Sierra Club, Hopkins Marine Station, AMBAG, Santa Cruz and Monterey counties, as well as the California Fish and Game Department, and San Mateo County, appeared to express their opinions. The speakers criticized the marine disposal plan and/or urged further and more intensive investigations in all areas related to the proposed outfall system.

B. Monterey Hearings

Not satisfied with the schedule of official hearings, the Monterey officials urged that hearings be held in the Monterey Bay area as well. Their requests were initially rejected on grounds that the region lacked a "legitimate interest" in the subject, but in October 1969, the State Water Resources Board finally consented to hearings in the cities of Santa Cruz and Monterey. Both sessions were heavily attended. At Santa Cruz, for example, where 150 had been expected, 500 actually appeared. The local press had played an active role in alerting and informing the public about the issues and events. Consequently, speaker after speaker arose to express either his personal disapproval or the doubts of the group he represented. The concept of marine disposal and the methods used to arrive at such a decision were attacked. While commending the regional approach of the plan, witnesses questioned the proposed low level of treatment and the conclusions about ocean current flows. Monterey County Public Health Director, Richard Fraser, M.D., articulately emphasized these points before the Board (40).:

> Recently, Monterey and Santa Cruz Counties, with the assistance of a number of other public and private organizations, conducted a study of the extent to which Monterey Bay is being polluted and contaminated. Regrettably, the results of the study showed conclusively that the Bay is being contaminated by sewage either incompletely treated or improperly discharged. In certain instances, the extent of the contamination was found to be such as to constitute a health hazard and, much as we hated to do so, we have taken the action to post signs on certain beaches warning the public against wading, swimming, surfing, skindiving or other water contact sports.
>
> As you might expect, the action to post certain of our beaches gave rise to considerable public indignation, part of which had its roots in concern for the Bay as a part of the local environment and part of which was aimed at the economic impact such an action was apt to have. It is fair to say, nonetheless, that no exception has been taken with the action to post the beaches; with singular unanimity, the voice of public opinion has accepted the necessity for that action and has urged those responsible to institute the corrective measures required to return the Bay to a condition considered safe for all uses . . .
>
> Mr. Chairman, I have taken the time required to review this background with The Board to emphasize two points:
>
> – First, Monterey Bay already has a sewage problem of its own which the residents of this area are working hard to resolve.
>
> – Second, Residents of this area will look with grave reluctance on any sewage disposal proposal which has the possibility of worsening the existing situation, or of replacing our current problem with a much greater one.
>
> With that background on hand let me now comment briefly on the San Francisco Bay-Delta Water Quality Control Program. As Supervisor Branson noted when he spoke to you earlier this year, we view with some apprehension and considerable reluctance the prospect of hundreds of millions – even thousands of millions of gallons of sewage being discharged into the ocean near San Gregorio Beach and Pescadero Point about 30 miles north of Monterey Bay. During much of the year coastal currents flow in a southerly direction and it seems to us that Monterey Bay could easily become the sump pit for the 12 counties that make up the Bay-Delta project. For that reason, and much as we applaud comprehensive planning for waste disposal of the type which resulted in this proposal, we would urge the Board to require the most exhaustive oceanographic and ecologic studies before any final decisions are made to go forward with this project. A definitive and conclusive determination that currents will not carry the Bay-Delta sewage into Monterey Bay should be considered a minimum essential requirement before any authorization to proceed is issued . . .

No adequate long-range current studies have ever been made of the northern Monterey Bay, so there could have been no way of knowing with certainty whether or not this tremendous mass would have swept into the Bay. Since the outfall would have been quite deep, the sewage might well have become caught under a thermocline and transported great distances with little mixing. Such a mishap occurred at the Hyperion outfall in Orange County, where massive contamination was found miles from the point of release (41).

C. Phase II: Down Under?

In November 1970, Walsh declared that the State Water Resources Control Board had unofficially "disowned" Phase II, but he also noted then that there are some people who feel that ocean dumping is inevitable with the expected increase in Bay Area population (42).

The State Board has not officially decided the fate of Phase II. (But the position of the San Francisco Regional Board is clear, as reviewed in the previous chapter.) Its December 1970 hearings on wastewater reclamation indicate that it is looking carefully at the reclamation alternative. Until there is official and

final rejection of the marine disposal plan, or unless further research demonstrates conclusively that no ill effects will occur, however, the Monterey area is remaining on its guard.

The intensity of concern, however, is noteworthy. It is clear that the inhabitants around Monterey Bay do not take water quality lightly. They place great importance on the uniqueness and beauty of their Bay and its value to the lives of those who live along its twenty-two mile shoreline. In addition to the important economic and recreational opportunities and the aesthetic enjoyment it provides, the Bay contains several coastal and undersea preserves. Recognizing its exceptional character, the State has protected its shores and the coast along Santa Cruz and Monterey counties by prohibiting any drilling or development for oil or gas, within the three-mile state limit. The Bay's diverse marine environments, some of the richest along the Pacific Coast, and its renowned submarine canyon, have lured numerous educational and scientific institutions to its shores – among them the U.S. Naval Postgraduate School, Moss Landing Marine Laboratories, Hopkins Marine Station of Stanford University, and the State Department of Fish and Game. In the opinion of Professor E. C. Haderlie of the Naval Postgraduate School, Monterey Bay is developing into one of the outstanding oceanographic centers of the world (43).

In spite of its importance to them, the people of Monterey have not always been alert and able stewards of their Bay. In recent years, problems of water pollution have become disturbingly apparent. Especially because of the effort and money they have spent to protect and preserve their Bay, the Monterey Bay communities view the San Francisco Bay-Delta program and its potential to undo their efforts, with great apprehension.

D. The Ocean Disposal Proposal

The debate on the marine disposal plans of the Bay-Delta program revolved around two fundamental questions: 1) What will happen to the discharged wastes in the ocean?

(The Bay-Delta study anticipates that currents will carry them out to sea where they will be dispersed and diluted into oblivion. More recent evidence indicates that the wastes may be transported back onto the shore or into San Francisco or Monterey Bay (2).) What will be the short and long term effects of large quantities of sewage on the biota and ecosystems of the ocean?

(A third and very important question exists regarding the possible occurrence of an earthquake and the consequences it would have on the sewer lines that will cross the San Andreas fault to the ocean. This possibility was the subject of an amusing commentary by a Santa Cruz official which we present in its entirety for your contemplation (See Figure 7-2). Our study here, however, will be confined to the first two questions, which were the major concerns of the people of Monterey.)

Qualified scientists in the Monterey region were extremely skeptical of the studies upon which the outfall decision was based. Both Dr. Stephens Tucker, professor of Oceanography at the U.S. Naval Postgraduate School, and Dr. John Harville, marine biologist at Moss Landing Laboratories, charged that the Bay-Delta conclusions on ocean currents were founded upon a cursory investigation and inadequate data (44). Dr. Harville, Dr. Welton Lee of Hopkins Marine Station, and Lance King, Santa Cruz University

student – persons familiar with recent marine sewage research – expressed vehement concern about the second question of sewage effects (45). At this point we shall examine the method by which the potential outfall locations were evaluated in the Bay-Delta program.

1. Bay-Delta Methodology

Based on the assumption that ocean disposal of wastewaters is a "logical and attractive" alternative to wastewater discharge into the San Francisco Bay and Delta (46), four potential outfall areas along the northern California coast between Bodega Bay and Point Lobos were selected for study. They were Estero de San Antonio, Pillar Point, Point Ano Nuevo, and Sandhill Bluff. At each of these sites, the following were examined: 1) the physical, chemical, and biologic characteristics of the surrounding ocean that would determine its assimilation capacity and dispersion ability; 2) the resources and beneficial uses that might be affected by waste discharges; 3) the construction cost and related factors of such a system.

The study of ocean currents and physical characteristics was conducted by the Engineering-Science, Inc. (ESI), which began by surveying the available information sources. Their discovery that very little information on California coastal waters exists, led them to conduct their own field research. Various measurements were recorded from 200 and 300 foot depths "on several occasions during the summer and winter of 1967" and at two sampling stations per site. From the obtained data and other sources of information, they calculated "zones of influence" or areas within which coliform concentrations would exceed 10 per milliliter. For calculation purposes, primary treatment without chlorination (in essence, "advanced primary" treatment) and specific discharge quantities were assumed. At Point Estero de San Antonio, the amount was 240 mgd; at Pillar Point, 1,300 mgd. No quantities nor explanations were mentioned in the Bay-Delta report for the other two sites. Outfall lengths and depths also varied from study area to study area (48).

A task force from the California Department of Fish and Game conducted a study for identification and evaluation of the beneficial uses of the marine environment, as well as surveyed benthic populations for each study area. To measure fish catches and fishing effort, as well as park use, they statistically analyzed information from fishing logs, commercial landing figures, attendance records, and personal communications with park and beach personnel. In the benthic survey, which was conducted by raw sampling, two additional sampling stations per study area were added to the pair designated by ESI. The Fish and Game researchers recognized that four non-random sampling stations were grossly inadequate as the basis for a valid assessment of benthic communities, but the constraints of time and money made the addition of more stations unfeasible. They proceeded with the survey only because the dearth of information on California benthos made any investigation, however, inconclusive, useful (49).

Despite the acknowledged and unacknowledged limitations of the Bay-Delta research, a location for ocean outfalls was identified on the basis of the available information. Point Estero de San Antonio was rejected because of probable damage to important commercial fisheries in the area, strong upwelling (which moves water toward the shore and encourages the surfacing of wastewater (Bay-Delta plans propose outfall

OFFICE OF CIVIL DEFENSE

DISASTER PLAN

COURSE OF ACTION TO BE FOLLOWED IN THE EVENT OF SUDDEN FAILURE OF THE BAY-DELTA SEWAGE TUNNEL UNDER FULL LOADING.

To the People of the Redwood City Area:

When the Bay-Delta sewage tunnel through the coastal hills is operating under a full loading and an earthquake suddenly cuts off the tunnel from its normal function of conveying sewage from the South Bay Area to the Pacific Ocean, there are certain precautions that should be observed by all people in this area to ease and alleviate the disaster, and it WILL BE a disaster when 500,000 gallons per minute of sewage backfire out of that tunnel.

AT THE FIRST SIGN OF AN EARTHQUAKE:

1. *Run into the street and yell "HERE COME DE SLUDGE," then RUN LIKE HELL FOR HIGH GROUND!*
2. *Do not delay, for within minutes footing will be slippery and precarious, and pedestrians may be swept off their feet and flushed into the Bay.*
3. *Carry a full canteen of water and an emergency food supply! It will be several days before the grocers can wipe off their stock and replace it on the shelves and in the bins.*
4. *DO NOT ATTEMPT TO DRIVE YOUR CAR! By the time you could get it into the street it will be TOO LATE! Even with skid chains streets will be impassable and chains will throw the mess as high as a second story window, which would be unpalatable, discomfiting, and discourteous to those who elect to remain upstairs during the horrendous happening.*
5. *DO NOT call the County Supervisors. The whole nauseous mess was not their idea in the first place. DO NOT call the County Public Works Department. They will probably think it is just another normal day in the Department.*
6. *After things dry out and service is restored, you may return home and attempt to clean up the mess. This will require both fortitude and ingenuity. DO NOT DISPOSE OF REFUSE BY FLUSHING DOWN THE TOILET! The aftershocks may reverse it right back in your face. Be extremely suspicious of candy bars and link sausages you might find or that may be offered to you.*
7. *Your lawn will now need mowing. DO NOT USE A POWER MOWER unless you are wearing hip boots and have a brown house and car.*
8. *KEEP COOL, CALM, AND COLLECTED! KEEP BOTH FEET ON THE GROUND AND BREATHE THROUGH YOUR NOSE! This is the price we must pay to maintain our status as the TOILET BOWL OF THE BAY AREA and the SLUDGE CAPITOL OF THE WORLD.*
9. *DON'T WAIT FOR YOUR BLOCK CAPTAIN! HE'LL BE AWAY AHEAD OF YOU!*

Figure 7-2

depths of approximately 200 feet); and extensive recreational and educational uses. Sandhill's Bluff's proximity to Monterey Bay and the profusion of resources and uses in that bay eliminated that site from the list. The remaining coastline, running from Miramontes to Pigeon Point was therefore designated as the best of the alternatives. The favorable outfall characteristics of the location included the smallest possible effect on fisheries, limited recreational use, lesser degrees of upwelling and onshore currents, a shorter continental shelf, and a stronger thermocline (a temperature gradient of the water, which presumably keeps the wastes submerged).

2. Ocean Currents

In selecting the Miramontes-Pigeon Point coastline, the Bay-Delta planners appear to have assumed that the identity and influence of the sewage effluent will be limited to areas of ocean waters equivalent to the zones of influence that were calculated for hypothetical outfall points in the area. The implication is that ocean transport of the effluent along the California coast is highly unlikely. Hence, they conclude that "ocean density structure and current patterns appear to be favorable for waste dispersion . . ." (50). Nowhere in their report, however, is there specific oceanographic evidence to support such a conclusion.

The summary of current patterns is a brief and general description of ocean currents in the area, e.g., "*Pillar Point* – The local current pattern in this area is complex. The USC and GS Tidal Currents Tables show tidal currents to be 'weak and variable' . . . The movement of water in this region during the Davidson Current Period (November-February) is a counter-clockwise eddy . . ." (51). No attempt is made to relate the description to the conclusions.

The lack of specific supporting evidence, however, is not surprising in view of the questionable field research methodology of ESI, which was, in fact, disqualified by the Fish and Game researchers in their report. Even a non-scientist can recognize the inadequacy of two sampling stations as data sources for analysis of current patterns, especially for regions as large as those that were studied. Furthermore, the period of data collection ran for less than a year. The Bay-Delta report itself acknowledges the seasonal changes which logically could not have been evaluated with less than a year's research.

3. **Naval Postgraduate Studies**

A comparison of the Bay-Delta methodology with that of two recent oceanographic research projects by masters candidates of the Naval Postgraduate School exposes some of the deficiencies of the official study. The comparison is convenient because each of the Naval Postgraduate researchers included in his study area the very coastal waters involved with the proposed outfall system. In contrast to the Bay-Delta's six sampling stations, Baker and Labyak occupied 79 and 86 oceanographic stations respectively spread out between Monterey and San Francisco during a one-week period in November and May respectively. Their conclusions are properly confined to the respective oceanic season in which their research was conducted. Even with the large number of stations they occupied, their conclusions are narrowly and tentatively drawn; they both understood that their research and results are only a small part of understanding the currents in the area.

If the Bay-Delta analysis were based on exhaustive and well-substantiated previous research, the inadequacy of their field methodology might not have mattered. The fact is, however, that very little is known about California coastal currents. What data there is raises serious questions about the Bay-Delta findings and conclusions.

4. CALCOFI Investigations

In 1958, the California Cooperative Oceanic Fisheries Investigations (CALCOFI) charted the geostrophic flow of the California Current, the major current that flows southward along the coast for most of the year (Jan/Feb-Sept). Geostrophic currents are hypothesized from horizontal pressure gradients of the ocean, as determined by salinity, temperature, atmospheric conditions, and the effect of the coriolis force of the earth's rotation. Their accuracy, according to Dr. Tucker, is greater than that yielded by a few direct measurements (52). Ongoing research by the U.S. Geological Survey utilizing bottom drifter tracers may provide even more accurate data, but as of January 1971, no conclusions were available from them.

To a layman, the striking feature of the geostrophic charts is the number of localized eddy systems that are suggested along the California coast. Eddy systems can cause the discharged wastes to circulate around the outfall locations rather than disperse. Although the Bay-Delta report mentions local currents, it does not attempt to demonstrate how the specific eddy systems in the selected outfall area affect the dispersion capacity of the ocean. According to Paul Wild, one of the Fish and Game researchers, no one really knows what the local current patterns are like at the present time (53).

The recent Naval Postgraduate investigations made several tentative, but applicable findings about the larger currents. Baker concluded from his November research that, during the Oceanic Period (Sept-Nov), the California Current flows southward along the coast above 60 meters (the outfall depths proposed average 200 feet or roughly 66 meters) until it reaches Monterey Bay, where it sinks to 60 meters as it enters the cove (54). Labyak, who conducted his study in May (a month which was not covered by the Bay-Delta investigation) observed a water mass moving from San Francisco Bay to an area between Pigeon Point and Point Ano Nuevo where it then surfaced (55). These observations, while not disproving the Bay-Delta findings, offer a serious challenge to its conclusions.

Both Labyak and Baker also made an interesting observation about the thermocline, a border phenomenon that forms between two water masses – one above the other – whose temperature and subsequent density differences cause them to act as almost independent masses (56, 57). In analyzing particle distribution, they confirmed that a majority of the particles are located either at the top or the bottom of the thermocline. The Bay-Delta planners felt that the presence of a strong thermocline was beneficial to an outfall site because the stratification would keep the wastewater field submerged. Thus, a strong thermocline was mentioned as a positive characteristic for the selected Miramontes-Pigeon Point area. Their assumption may be true, but if particles tend to congregate in a particular portion of the ocean, this would imply that diffusion is decreased. In fact, in one of the interviews, a case in southern California was cited in which "blocks" of sewage, traced back to Los Angeles, were discovered, undispersed, about a hundred feet

below the ocean surface near Orange County, some ninety miles away (58). Such a phenomenon raises important questions about the fundamental assumptions concerning ocean transport and dispersion.

From late November to January, a strong north-bound counter current develops along the coast suggesting that the people of San Francisco Bay may not escape their sewage problem even with marine disposal. The Bay-Delta report contends that no danger from the Davidson Current will exist because the current tends to run parallel and near to the coast while the outfalls will extend a considerable distance from shore, but little evidence is given to develop this claim.

The fact remains that very little is known about coastal currents. The general picture that emerges is one of variable seasonal patterns, complex local currents, and many unknowns. This is summed up in the Fish and Game report that was prepared for the Bay-Delta study:

> The prevailing California Current flows in a southerly direction. During the winter months the nearshore Davidson Current develops, flowing in a northerly direction. Little is known of the effects of these major current systems and local conditions on the circulation patterns. It is not now known whether or not waste discharged here (Miramontes Point to Pigeon Point) would enter the Gulf of the Farallones current regime, the Monterey Bay current regime, or be dispersed into the major systems (59).

5. Basic Assumption

A major problem with the Bay-Delta oceanographic investigation is its basic assumption that an ocean outfall is desirable; indeed, that marine disposal is inevitable if Bay-Delta waters are to be protected. Couched in such a framework, the analysis becomes a comparison of the four potential outfall areas rather than a feasibility study of the marine outfall concept. The possibility that ocean disposal might not be desirable at all is never confronted.

The comparative nature of the Bay-Delta assessment becomes obvious with a close examination of their conclusions. The coastal waters between Miramontes and Pigeon Point were favored because they were perceived to have a "*more* pronounced thermocline," "*less* upwelling" and "*smaller* on-shore currents" than the other locations (60) (emphasis added). The Fish and Game task force was required to work within the same framework in their study of beneficial use and benthic populations. Consequently, they concluded that the "least damage" to fisheries and public use would occur along the chosen coastline (61).

The Fish and Game report, however, made it very clear that the Miramontes-Pigeon Point coast presently serves some valuable public uses. Numerous state parks, for example, are located along that coast, and although limited access presently discourages public use, future patronage is expected to greatly increase with the planned expansion of several State parks south of San Gregorio Beach. One wonders whether future beneficial uses were considered by the Bay-Delta planners, especially in light of the rapidly increasing recreational activity of Californians (62).

Other beneficial uses include valuable shore and nearshore sports fisheries (some of the highest catches per hour have been made off Pigeon Point), large supportive bottomfish populations, and a commercial shellfish hatchery. According to the Fish and Game study, the latter two resources would be directly and detrimentally affected by any large outfall system (63).

Nevertheless, the Fish and Game researchers, according to their own testimony (64), *were not allowed to conclude that an ocean outfall was desirable* for all the candidate sites. Bay-Delta orders requested a designation of the area in which marine disposal would have the least adverse effects, and no more.

Even so, the Fish and Game report that was submitted in the Bay-Delta study group contains carefully-drawn qualifications that warn against the hazards of marine disposal. It is revealing to compare that report with the final Bay-Delta report because of the striking contrast of philosophies. From the beginning of the Bay-Delta chapter on oceanographic studies, the guiding assumption is made clear:

> Disposal of wastes to the ocean is practiced by coastal and near-coastal cities all over the world. The reasons for this are simple and obvious. Usually the discharge of a given quantity of waste to the ocean will have far fewer adverse effects than the disposal of the same wastes to inland waters. Conversely, the expenditure of a given quantity of money for waste disposal will result in a higher degree of resultant water quality if the wastes are discharged to the ocean than would be the case were they to be discharged to inland waters. This is true because of the vastly greater quantities of water available for dilution and dispersion in the ocean (65).

The Fish and Game report, on the other hand, warns:

> In the past, man has consistently overestimated the capacity of his environment for waste assimilation ... The ocean, like other ecosystems, has a limited capacity for waste disposal ... Determining the placement of a marine waste outfall is not a question of finding a desirable location, but rather, finding one where it would have the minimum of adverse effects. Introducing any artificial changes into a natural ecosystem which has maintained an ecological balance for eons is indeed risky ... Changes inflicted on the environment can be irreversible (66).

This opinion, however, does not appear in the final report of the Bay-Delta program.

6. Effects of Waste Disposal on the Marine Environment

The basic differences between the Bay-Delta and the Fish and Game reports stem from the discrepant answers each research group obtained to the second major question concerning an ocean outfall system: What are the short and long term effects of waste discharges on the marine environment and biota?

To answer the question, the Bay-Delta study group examined the marine outfalls presently in operation in Southern California. They summarize the "important aspects" as follows:

* The amount of bottom fauna was similar to the amount found over the entire Southern California mainland shelf.
* Reduction in kelp populations, which has been associated with wastewater discharge, appears to be due to discharge of particulate solids and increased predator populations. Outside of the initial dilution zone, wastewaters may have a beneficial effect on kelp.
* An extensive trawl study from 1958 through 1963 determined that abundance of fish was unrelated to wastewaters in Santa Monica Bay and that the sportfishing catch during these years showed only small natural fluctuations.
* Based on findings to date, plankton populations are not strongly influenced by wastewaters in Santa Monica Bay (62).

These observations, along with their oceanographic information, lead the Bay-Delta planners to conclude that while ecological modifications might take place in the mixing zone, there was "insufficient evidence to predict whether such changes would have a net beneficial or detrimental effect on the quality and numbers of marine organisms harvested by man." The uncertainty notwithstanding, they also claim that due to currents and dispersion, "no significant ecological changes near shore" would result (68).

Data from existing marine outfalls, however, can be interpreted to suggest the precise opposite conclusions, as reported in the Fish and Game report. In the early 1960's, a four-year survey of marine sediments off southern California was conducted by the Allan Hancock Foundation of the University of Southern California. The biomass analysis of the Hancock study was one of the findings used by the Bay-Delta team to conclude that the impact of the proposed outfalls upon the marine environment would be minimal (69). What the Bay-Delta report did not note was the Hancock finding which the Fish and Game report cited:

> Large ocean outfalls such as the Hyperion outfalls of the City of Los Angeles and the Whites [sic] Point outfalls of the Los Angeles County Sanitation Districts, each with 275 mg/d (presently each about 330-350 mg/d, authors) and the Orange County Sanitation Districts outfall with 55 mg/d, discharge the wastes of great metropolitan areas into limited areas of coastal waters. *All profoundly affect benthic organisms*, with effects visible within measurable distances from the ends of the discharging lines (70). (emphasis added)

A recent study by Grigg and Kiwala has identified one of the mechanisms by which waste discharges affect and harm the marine environment (71). The investigation examined the sublittoral environment off White Point, which at the time of study in 1969, was receiving 360 mgd of wastes, 45-65 feet from shore at depths of 165-195 feet. "Large scale ecological changes" were observed – in particular, a sharp reduction in the diversity of eipbenthic species. A negative correlation between the number of species and the amount of sediment (which decreased with distance from the outfall) indicated that the changes were being caused primarily by the excess of organic-laden sediment which modified or eliminated the substrates essential to the epibenthic species and their larvae. The marked reductions in fish and abalone populations were attributed to the absence of algae and other plant material. Effects reached as far as six miles from the outfall; commercially valuable species such as abalone, giant kelp, spiny lobsters and fishes, which are normally present, were either rare or absent even in the area of least sediment.

In other marine studies, the toxicity and turbidity effects of wastes have been determined or suggested. Labyak noted that even in the ocean, sewage affects the transparency of the water, thereby influencing the availability of light for photosynthesis (71). Reich in his study of algae in Los Angeles and Long Beach harbors identified toxicity and turbidity, in addition to substrate modification, as lethal factors (73). Recent research at Hopkins Marine Station has been examining the same mechanisms (74). Marine sewage research is admittedly young, but evidence appears to amassing which indicates that waste effects upon the ocean environment are harmful.

The Bay-Delta Report contention is, however, that the dilution and dispersion powers of the open

ocean will render any toxic constituents harmless. The report notes that the coastal waters off San Mateo have an assimilative capacity superior to the capacities of the southern California locations. Furthermore, the outfall lines will extend four to seven miles from the coast. The claim is that a dilution of at least 100:1 will be achieved in the initial mixing zone. This is likened to a treatment process (allegedly far superior to most available treatment processes) in which concentrations of every constituent is reduced by 99 per cent.

Prior considerations of local eddy systems, currents, and the thermocline phenomenon have already posed questions about the validity of the dilution assumption. The uncertainty is aggravated when one recalls that the Bay-Delta discharge will far exceed the southern California quantities; one billion gallons each day, day after day, is no small amount.

Even if the assumed dilution did occur, however, it would not be adequate. Dilution is not analogous to waste treatment. The 100:1 dilution may disarm the coliform concentrations (though there are doubts even here), but it will definitely not, for example, solve the problem of biological magnification. In this process of nature, even trace quantities of heavy metals and chlorinated hydrocarbons will be picked up by organisms and passed along the food chain in increasing concentrations. Although initial dispersion may reduce potentially toxic substances into extremely tiny particles, these particles tend to be highly persistent and will adhere to small pieces of food such as algae. When the algae are eaten (usually in tremendous quantities) by a fish, the particles collect in the parts of the fish's body to which they have an affinity. In the case of DDT, for example, the fat-soluble chlorinated hydrocarbons accumulate in the fatty tissues of the organism. Through one mere link of the food chain, concentrations may increase a hundred- or thousand-fold, A larger fish or another predator then eats several contaminated fish and the concentration is thereby magnified once again until deleterious consequences begin to occur.

The Redwood City plant would have been unable to remove metals or pesticides. In fact, the ocean's dilution capacity was assumed to eliminate most of the problems that plague sewage disposal in confined waters. Therefore, the constraints that would normally be imposed on waste discharges would not have been applied to the Bay-Delta marine discharges. The high degree of pretreatment of industrial wastes that is required for Bay disposal, for example, would have been waived. The treatment at Redwood City was planned to be minimal – the "advanced primary" treatment consisting of screening and grit removal, followed by dissolved air flotation (a procedure in which air is forced through the influent to encourage oxidation and the breakdown of oil and grease particles and other floatables). No chlorination was planned (75). According to the Bay-Delta report, the process would have removed 55-65% of the suspended solids, 60-70% of oil and grease, and 40-50% of the biochemical oxygen demand, thereby fulfilling the recommended ocean discharge standards. The figures appear to be a bit excessive, however, for primary treatment, which includes a sedimentation process that is not part of the advanced primary process, is generally credited with removal, at maximum efficiency, of only 40-60% suspended solids and 30-40% BOD (76). Thus it appears that the main target of the Bay-Delta treatment process would have been the floatable materials. This would leave a motley collection of wastewater constituents from human, animal wastes, and household wastes, ground and storm waters, and industrial wastes. These would have included chemicals

such as mercury (frequently used as a fungicide in diaper cleaners), pesticides, disease-producing organisms, and nutrients such as phosphates and nitrates. Some constituents would be rendered harmless by dilution; others would not. In many cases, the exact effects are not known. The Bay-Delta report claims, for example, that biostimulants which are undesirable in large quantities in an enclosed estuary may beneficially increase the productivity of coastal waters, but no study has yet demonstrated this.

While data on the immediate effects of wastes on the marine environment is now fairly rapidly, though not reassuringly, accumulating, certain problems arise in the interpretation of some of the existing data. Results often show that certain species flee from the area or are killed off in the location of an outfall. At times, they also reveal that more tolerant species then proliferate to take the place of the more sensitive organisms. Unless the reduced species are commercially valuable or one is a lover of all living things, it is difficult for most people to see that any harm has occurred. Thus, while the Bay-Delta report admits that ecological changes take place around a marine outfall, it declines to identify such changes as detrimental.

The problem here is that the newness of marine disposal research has not allowed investigators to go beyond a description of immediate effects to look at the coastal and oceanic ecosystems and to determine what happens when wastes are injected into the waters over an extended period of time. Nevertheless, from his experience with and observations of other population groups and ecosystems, the ecologist can often at least identify the danger signals; he knows, for example, that any rapid and sudden changes in an ecosystem generally foreshadow adverse events of various sorts. He is aware, too, that long-range effects frequently remain hidden from man until it is either too late or the situation is extremely critical. A case in point is the DDT crisis.

One of the possible danger signals in marine sewage research is the reported reduction in diversity that waste discharges seem to cause. The threat of such an occurrence may not be readily apparent, but to the ecologist, a decrease in the number of species in an ecosystem is like the severing of a few supporting cords of a trampoline; the dependence of the system on fewer elements or links increases its instability and vulnerability to disaster. The point is that man is drastically altering his environment in ways that he is not aware of. Applying the rule of nature that everything is linked to everything else means that man himself will eventually feel the effects of that alteration.

7. The Value of the Coast

Exactly how man will be affected is difficult to predict. One remarkable finding advises extreme caution in any action that might modify the marine coastal environment.

In an article in *Science*, John Ryther analyzed the productive capacity of different parts of the ocean on the basis of primary production rates and food chain dynamics. He concluded that 90% of the ocean is virtually a "biological desert," with little potential for future productivity. It appears that only one-tenth of one percent of the ocean's surface produces half of the world's fish supply. Included in this tiny but fecund percentage, along with the upwelling regions off Peru, are the upwelling waters off the California coast. The other half of the fish catch is supplied by fertile coastal waters and a few offshore regions (77). Inter-

estingly enough, the waters off San Mateo fall into both the upwelling and coastal categories.

If man ever attempts to farm the sea on a larger scale, he will probably turn to the coastal and upwelling regions of the ocean. If he is careless, however, he could forfeit that option.

8. **Alternatives to Marine Disposal**

Interviews with Monterey Bay area leaders and officials did not uncover a comprehensive alternative plan to the Bay-Delta program. The suggestions that were offered were general and lacked detail. However, they revealed the nature of attitudes in the Monterey Bay area toward wastewater management and are summarized here because they represent a basic and important alternative philosophy to the ocean outfall rationale.

The danger to their bay aside, the leaders of Monterey criticized the inadequacy of the Bay-Delta recommendations for solving wastewater problems. In the words of Dr. Harville, marine disposal was "ducking the real solution for expedience." (78) Henry Mello, Santa Cruz supervisor, said that the Bay-Delta program was simply moving the problem – "hiding it for a while," but not solving it (79). Dr. Lee pointed out that the plan was typical of man's old habit of escaping rather than confronting the problem (80).

There was a strong consensus among the interviewees that the real solution is wastewater reclamation. The Bay-Delta program does include a Phase III in which partial reclamation is presented as a possible option in 1990. The Monterey people, however, envisioned reclamation as a substitute for rather than an adjunct to, Phase II.

None of the proponents went so far as to suggest that restoration of wastewater to potable quality is immediately feasible, but they were convinced that recovery of wastewater to that degree would become possible and economical in the near future. Indeed, they felt that reclamation is inevitable in light of the projected water shortage in 1990, and they urged that presently feasible uses of reclaimed water be explored now. They proposed a host of uses including Delta outflow supplementation, industrial cooling, landscape and agricultural irrigation, and the re-charging of ground water and lakes. According to Henry Mello, studies indicate that there are already agricultural markets for reclaimed water in Napa and similar agricultural areas (81). The future water shortage was seen as a compelling rationale for recycling of wastewater, because it would alleviate both water pollution and water supply problems. Taken in the long run and considering all costs, claimed Dr. Lee, reclamation would be the more economical route to choose.

The interviewees seemed well aware of the two corollaries to reclamation: careful planning and a regional approach, both of which they heartily endorsed, pointing to AMBAG and its plans for a comprehensive study of their bay area as evidence. In fact, one plan already exists for the regional reclamation of wastewaters in South Monterey Bay. It was cited as an example of the reclamation approach to wastewater management (82).

Dr. Lee suggested that careful planning, not only of water quality control, but of land use and population migration, would enable the most efficient use of reclaimed water by keeping water transport to a minimum. He was also highly critical of the Bay-Delta assumption that large quantities of waste from all

over the Bay might be adequately treated by one plant at Redwood City. There was no way, he contended, that a "mixed bag" of sewage could be effectively and efficiently treated. He proposed that agricultural, industrial and municipal wastes be kept separate and be treated according to their specific nature: a central collection point should be established for agricultural wastes where pesticides, nitrates and phosophates would be removed, and the water recycled for irrigation (this problem, appatently, is a technological thorn). In the case of industry, the responsibility should be placed upon the polluter to make his sewage treatable. He cited the case of the city of Salinas where, by a city ordinance, industries (primarily food processing companies) are charged for their wastewater loads according to toxicity and volume. Because of the costs they are incurring, the companies are now exploring inplant treatment which may be less expensive to them. Muncipal wastes, Dr. Lee said, should be recycled and reused (83).

A couple of interviewees conceded that some sort of ocean outfall might be necessary, if only as an emergency measure, but they felt that the discharges should be much smaller and the treatment much higher, with secondary treatment as the minimum.

Several persons called for changes on the level of the individual. A curtailment of excessive household water use was discussed by Mr. Sidney Brooks, director of the Council for Monterey Bay, Inc., and Dr. Harville. Required would be a massive and effective educational program and/or a sewage tax, measured by meters, much in the same way water consumption is. It was noted that the money spent on an effective educational program, if such were possible, would be much wiser than the investment of huge sums of money in pipes that would take sewage out of sight and mind (perhaps not even that) and mislead the people into thinking that all was well (84). Mor Robertson, manager of AMBAG, felt that a change from the "Madison Avenue" way of life and a general lowering of affluence was necessary (85).

IV. Conclusions

The Monterey Bay area is fortunate, as is San Francisco Bay, that the San Francisco Regional Water Quality Control Board is not supporting Phases II and III of the *San Francisco Bay-Delta Water Quality Control Program* but rather has elected the plan outlined by the *Interim Plan*. The latter approach takes more cognizance of our ignorance of marine biology and does away with the central Redwood City plant and the ocean outfalls. It further represents a major rejection of the concept that dilution is the best policy for ocean waste disposal. While from a theoretical engineering standpoint reductions of 99 + percent should result from this approach, we have indicated that complete mixing does not, in fact, occur. Because of thermoclines, current patterns, and other oceanographic phenomena, wastes discharged into the seas often do not disperse but form veritable "sewage lakes." Even if these facts of oceanographic life did not exist, discharging minimally treated wastes would have profound effects on marine ecology because of *biological concentration*. The classic case of this involves DDT in the food chain. The concentration of this pesticide is normally zero parts per million (ppm) in the water; the smaller fish contain around 0.25 to 0.5 ppm, while the larger fish have 1.2 ppm. Birds, such as terns, which feed on these fishes, contain 3 to 10 ppm, and the large diving birds run twenty or thirty ppm. This is about a million times the concentration in the aquatic environment.

Regional approaches to water pollution control are essential if we wish to have wise management of our water resources. Such studies, however, must evidence greater insight into the relevant biological and oceanographic variables. It would be the height of folly to implement Phase II of the Bay-Delta report without conducting much more thorough current studies so that we would know just whose nest we really were fouling. It might well be our own.

FOOTNOTES

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Chapter Eight

ACCESS TO INFORMATION ON NUCLEAR POWER PLANT SITING: ORCHESTRATED CONFUSION

Since the start of this volume we have moved from an examination of the history of water planning in the State of California, through an analysis of water resources in the San Francisco Bay region, to a discussion of the impact of the California Water Plan on the North Coast region and the San Francisco Bay Area. As we have seen, though, San Francisco is also in a position to affect other areas, particularly the Pacific Coast and the Monterey Bay region. Fortunately, both the public and relevant governmental agencies have realized this.

The second and third Phases of the *San Francisco Bay-Delta Water Quality Control Program* lack governmental approval, and current trends indicate that the State Water Resources Control Board will not approve implementation of this plan. The *precise* consequences which this waste water disposal program would have generated are unknown. As we have reviewed, our knowledge of current flow patterns off the California Coast is miniscule. Such ignorance makes comprehensive, long-range planning difficult; the Bay-Delta Program, which in many ways might appear a very sensible proposal if its underlying assumptions had been accurate, could have produced a many-headed monster which would have ultimately wreaked havoc along a large portion of the northern Pacific shoreline. Until such time as we can be truly cognizant of the consequences of our long range water disposal plans, both to the entire ecosystem and to man as a part of that system, we had best act within the bounds of our knowledge.

I. Nuclear Power

The San Francisco Region not only has water resource needs and waste water disposal requirements but obviously enough energy needs. At present this is supplied by six fossil fuel generating plants scattered throughout the Bay Area (1). For numerous reasons, the Pacific Gas and Electric Company plans to meet additional future needs through nuclear power generating plants. The wisdom of such plans, both on a local and national basis, is unfortunately beyond the scope of this volume. The reasons for such development are

important and deserve evaluation and discussion. That there are alternatives to nuclear fission plants nearing prototype development and which would not present some of the potential pollution hazards of fission plants is also, unfortunately, beyond the scope of this volume.

Because of social, economic, and other considerations, most nuclear fission electrical generating plants are located in rural settings, well away from the urban complex which depends on the energy they produce. The way in which such a plant produces electricity is not magical. In fact the thermodynamic energy conversion in nuclear power plants is less efficient than in coal driven power plants. Simplistically, a nuclear reactor is substituted for a coal burning furnace. The reactor generates heat, producing steam in a boiler which drives the electric generating turbines. Some of the advantages are that coal, and other dwindling fossil fuels, will be saved and that nuclear fuel does not emit the carbon monoxide, nitrogen oxides, sulfur oxides, and other air pollutants. On the negative side, nuclear reactor wastes are extremely difficult to dispose of, and there is still a large amount of waste heat generated. This latter must be dispersed and since nuclear plants will ultimately be larger than existing fossil fuel facilities, they will need large volumes of cooling water. This has prompted many utility companies to favor coastal sites for future generating plants.

A. Nuclear Power Plant Siting in California

Pacific Coastal sites have, of course, been favored by the Pacific Gas and Electric Company (PG&E). Once again, however, the biological and oceanographic consequences of discharging thermal and radionuclide pollutants into the Pacific Ocean are poorly understood (2).

PG&E is cognizant of this and has worked cooperatively in the past with various state agencies (3). Despite this concern and our oceanographic ignorance of Monterey Bay (See Chapter Seven), PG&E has been seriously considering placing a nuclear generating facility at Davenport, immediately north of Santa Cruz (See Fig. 7-1).

1. Calefaction

The study of increasing water temperature is still so young that biologists cannot really state for certain whether such changes are deleterious. Consequently, until we possess more evidence, some recommend the neutral term, calefaction, meaning to make warm, as opposed to the perjorative term, thermal pollution (4). Preliminary studies of thermal wastes from nuclear power plants indicate that short-term changes in fresh water systems are minimal. The long term consequences are pending. Since electric power generation is expected to nearly double during the next decade, it is vitally important that we determine what effects elevating water temperature does indeed have (5). There can be little question that there will be effects. Whether they will be what human society would term good or bad cannot yet be decided.

2. Siting

Because of the obvious importance many nuclear power plants would have for the State of California

and all the residents of the State's ecosystem, we thought it would be useful to investigate the procedures which eventually place a nuclear power plant at a given location. Additionally, this topic provides us with an excellent case study in public affairs-environmental decisionmaking. It further involves the basic concepts of freedom of infoimation and what former President Lyndon Baines Johnson termed "the people's right to know."

II. Orchestrated Confusion Begins

In fiscal year 1968 the Atomic Energy Commission conducted twelve public hearings on the issuance of construction permits for nuclear power plants. Six of the hearings were uncontested. In fiscal year 1971 the AEC projected that of eleven hearings for construction permits, all but two would be contested, and all nine operating license hearings would be contested (6). In the days when the public was relatively unconcerned about the hazards of air and water pollution and excess radiation, and unmoved by the despoliation of coastline or scenic rivers, the electric utilities were able to site their plants – hydro, fossil fuel, and nuclear – according to the economic ethic of the most power at the least cost. As part of the mounting concern in the past two years over the deterioration of the environment, the public and such action groups as the Sierra Club have begun to demand a more important role in siting decisions.

In California, legislation was introduced in Sacramento in the 1970 and 1971 sessions to provide the State with authority over the siting procedure. Bills were drafted by the private utilities, the public utilities and the Sierra Club. President Nixon in early 1971 offered his own bill on state control of power plant siting. And the Southern California-based People's Lobby began gathering signatures to a petition which, if it reaches the ballot in June, 1972, and is passed, would impose a five-year moratorium on the construction of nuclear power plants.

The scramble for access to the siting procedure is prompted by figures from The Energy Policy Staff of the Office of Science and Technology, which predicts that by 1990 the utilities will have to construct 255 *new* thermal generating plant sites of 500-megawatt capacity or larger; it is also predicted that 164 of the sites will be nuclear, and 91 will be fossil fuel plants (7). Ten of these sites will be needed in California, six in northern California (8). The total number of thermal generating plants in the United States will more than double in just the next 20 years. The implications of these figures are just beginning to hit home to the environmentally-conscious public, prompting the confusion which now surrounds the siting procedure.

Before examining this procedure as it now exists in California (and the role of the public and its access to information in that procedure), it is necessary to understand some of the basic assumptions held by utility and government planners and to examine the framework within which siting decisions are currently made.

A. Utility Assumptions

If the repeated brownouts and blackouts in New York City have been burdensome on that city's residents, they have been of propaganda value to utility and AEC spokesmen around the country. The

brownouts play a major role in the industry's dire predictions of what will happen if more power plants are not built – fast. While no one doubts the definite power crisis facing the Northeast, the brownout psychosis has succeeded in limiting the scope of the power debate nationally to the location of future plants and the type of fuel to be used. Foreclosed are discussions of the overall relationship of population increase, population density, and electric power; alternate solutions to the power shortage other than the construction of more generating stations; and how critical outside the Northeast that power shortage really is. The urgency with which the utilities and the AEC argue has also precluded serious research attempts at developing methods other than the use of fossil or nuclear fuels in the generation of electricity. Because the nation may be near to a general brownout, the industry must push ahead in the advancement of nuclear power technology, at the expense of research into other technologies. It is perhaps in the nature of a bureaucracy that such philosophic and policy questions are difficult to bring into everyday decisionmaking; but it is significant that the public siting struggle being waged today is almost totally bereft of this larger vision.

In California, utility officials, state officials and planners within the Resources Agency, the Public Utilities Commission, and the Atomic Energy Commission (the four important power blocs in the siting procedure) are all committed to the rapid facilitation of utility plans for more power plants, and to the notion that these plants be nuclear. In authorizing the preparation of the report *Siting Thermal Power Plants in California* (February 15, 1970), the California State Assembly noted:

> WHEREAS, The continued growth of California and the welfare of its people are vitally dependent upon the reliable availability of electric power; and
>
> WHEREAS, California electric power demands are doubling every eight years, and by the year 2000 will approximately the 1968 power consumption of the entire United States; and
>
> WHEREAS, Most of the new plants will be nuclear, preventing air pollution and maintaining low power costs, but further limiting the choice of acceptable sites; and
>
> WHEREAS, There will be an increasing problem in establishing, on a timely basis, power plant sites suitable for their purpose and acceptable to the public, so that Califomia can avoid the power shortages which have occurred from time to time in other parts of the country; and
>
> WHEREAS, It is desirable for the public, the electric utilities, and the state to have a basis for future plans and commitments relating to power plant sites; now, therefore, be it *RESOLVED* . . .(9)

The report which resulted from this resolution states that "It is also the policy of the State of California to encourage the use of nuclear energy, recognizing that such use has the potential of providing direct economic benefit to the public, thus helping to conserve limited fossil fuel resources and promoting air cleanliness."(10) The State Air Resources Board is on record as favoring nuclear over fossil fuel plants because of the less objectionable nature of the air pollutants. The AEC, of course, promotes the construction of nuclear plants and aids the utilities in research efforts and in the procurement of fissionable materials without questioning utility projections of the future need for power. And the California Public Utilities Commission continues to concern itself primarily with guaranteeing to Californians the most power at the least cost.

In short, within the power planning and regulatory establishment there is not a single important

anti-nuclear power plant spokesman, nor is there anyone advocating solution of power shortages by any other means than the rapid construction of nuclear power plants. The only serious question is where to put them. Opponents do exist outside the planning structure.

B. Legislative Logrolling

The goal of the utilities in the current legislative logrolling taking place in Sacramento and Washington, D.C. is to cut down on the time required to license and begin operation of a new plant (either fossil fuel or nuclear) and to limit regulatory power to a State siting committee and the AEC. At present a utility can count on anywhere from six to nine years from inception of the plant to actual operation; some nuclear plants, most notably Consolidated Edison's Indian Point No. 1 plant, have been completed, yet are being held out of operation through court action, at an estimated cost to the utility of $50,000 to $100,000 a day. In writing such legislation as AB 818, introduced in 1970 and 1971 in Sacramento by Orange County Republican Assemblyman John Briggs, the California private utilities are trying to eliminate all local control over siting; grant to a State siting committee the power to decide on a site's environmental suitability; and leave radiologic safety questions to the AEC. President Nixon's bill would also streamline the siting procedure by allowing only two levels of effective regulation: a State siting committee to decide on environmental matters; and the AEC to handle nuclear safety. This is known as the "one-stop shopping" concept, and it was narrowly defeated in 1970 in Sacramento through the efforts of the Sierra Club.

The present system, which the Sierra Club is attempting to keep until it can devise an alternative, has more overlapping layers of authority and provisions for public participation (or at least harassment). Many local, state, and federal agencies now participate, and while they are all of the same mind, there are enough procedural delays built into the system to provide some checks and balances. The utilities claim they will not be able to meet the nation's power needs under such conditions. They charge such groups as the Sierra Club with being obstructionist.

Under the present system (and in all projected siting procedures for California), the initiative of developing a plan showing future power needs, and then selecting sites on which to build plants to meet those needs, rests solely with the individual utilities. Local and state agencies and the AEC are in a purely reactive position: they can say "yes" or "no" to a particular site, but they cannot plan with the utility at the outset. The State of New York recently authorized its Atomic and Space Development Authority to select, and in some cases acquire, sites for plants and then sell them to the utilities (11), but there is no enthusiasm for such a plan in California. The usual argument is that the state should not be in the siting business, and that planning is a utility function and responsibility best performed by experts. Because the regulatory agencies are so in tune with utility thinking that they rarely disapprove a utility-selected site, these early decisions are the *most* important in the siting procedure yet they are made with the least public knowledge: behind closed utility doors, without supervision by state or federal officials, and without input from conservation organizations and the public.

Not only does the siting initiative rest with the utilities, but the major responsibility for gathering

environmental information about the proposed site before construction begins, and for monitoring the effects of the plant on the environment, also rest with the utility. No local or state government agency has the money or manpower to conduct the enormous geologic, hydrologic, meteoroligic, or other studies necessary to determine the suitability of a site, and so the utilities take this over by default. A number of men within the Resources Agency in Sacramento are well-qualified to assess the information brought them by utility engineers or their paid consultants, but again they are in a reactive position. The utility is calling the basic shots. All of the agencies in the procedure which must in theory, independently pass on the environmental suitability of a site are relying on the State Resources Agency people, who are in turn relying on the utilities. While no one even implies that the utilities are playing fast and loose with the data they collect, it is nonetheless a strange regulatory scheme in which the business being regulated provides most of the basic data.

These prefatory remarks should help the reader understand the detailed siting procedure which follows, and the motivations behind it. In siting, the utility will usually work from local government agencies up, so that is how the material has been organized.

III. The Utility and Secrecy

Despite the bitter opposition of some of California's conservationist groups, the electric utilities have in general enjoyed the faith and trust of the people of the state. A 1967 public opinion poll, commissioned by six major California utilities and two reactor systems manufacturers, showed that over 70 per cent of the public believed that a utility *would not build* a nuclear power plant where there would be any danger to the public. In addition, 73 per cent believed the plants "are necessary to supply additional electricity for California's growth and progress"; and 51 per cent felt that "providing a new source of electricity is more important to the community than keeping the land and wildlife the way they are." (12) Thus, a most important advantage to the utility in the siting procedure is that it starts with the confidence and sympathy of a majority of the public.

In a general way in the past couple of years there has been pressure on the utilities to make known their siting plans. In the previously mentioned report to the California State Assembly, *Siting Thermal Power Plants in California*, the utilities made public their plans through 1990; that is, how many more sites are likely to be needed, that they likely will be coastal sites because of the economies of ocean cooling water and the scarcity of fresh flowing water in California, and the expected balance between fossil fuel and nuclear plants to be constructed. Such long-range reports have been institutionalized through AB 1247, passed in 1970, which directs the Resources Agency, in cooperation with the utilities and the PUC, to develop a 20-year plan identifying power plant "locations suitable from an environmental standpoint." The project is funded with $150,000 from the environmental fund collected from the selling of personalized license plates. Also with an eye on the environmental movement, the PUC, on July 1, 1970, in its General Order No. 131, ordered the utilities to submit each year a ten-year forecast of loads and resources, and a description of the generating and transmission facilities which will be required to meet those forecasts.

Biennially each utility must submit a twenty-year forecast. Naturally, such information is available to the public (and press), either from the Resources Agency or the PUC.

Specific sites under consideration are another matter. At any given time PG&E may have up to 130 different sites under consideration, but until the utility has taken an option to purchase the land, it is extremely reluctant to disclose which sites are receiving special attention. PG&E did not officially announce that Bodega Head was to be the site of a plant until after a portion of the land had already been purchased. The usual reason given for the utility's reluctance to discuss specific sites is that if a landowner hears in advance that PG&E is interested in his land, the price will go up. Both public and private utilities have condemnation powers, so that if the utility and the landowner cannot reach a settlement satisfactory to both, the sale goes into the courts, where a price is decided by a condemnation jury. The utility feels that it receives less than a fair shake from these juries, although there is no evidence to support this claim. A PG&E spokesman said the utility does not like to use the condemnation power because it can be accused of abusing it, and this is bad public relations (13).

There are two other reasons for utility secrecy at this early stage. Speed is of the essence to a utility, and jury proceedings can take up valuable time, especially considering delays to be expected later. Second, and more important, once the utility has decided on a site, it wants to get as deeply involved in it as possible before coming under public scrutiny, so that if public opposition develops, the utility can use the "prior investment" argument to keep the site alive.

Within PG&E (one of the nation's more progressive Investor-Owned Utilities) there is some evidence of change on this point. A few officials recognize that there is a difference in the way PG&E ought to conduct itself, and the way in which Standard Oil or General Motors, truly private companies, can make decisions. "We are responsible to the public in all ways," said former PG&E engineer Gene Blanc, "and we must do all things in the public eye. But it may take a generation to change – and we may not have a generation." (14)

The only role the public now plays at this site-selection stage is through the accumulated pressure of the environmental movement. There is, according to Blanc, a tremendous philosophical battle going on at the highest levels of management over how much concern to give to the environmental question. After World War II PG&E, partly at the urging of the PUC, which wanted the most power at the least cost, began to think of its fossil fuel plants as industrial endeavors. None of the environmental concern that had been present in the site of hydroelectric plants was carried over into the planning and operation of these plants (15). Now, this cavalier attitude toward the environment has come home to roost. Undoubtedly a number of otherwise perfect sites for nuclear power plants (such as on estuaries) are vetoed immediately because of the predictable public outcry.

At an early stage it does not seem that the siting plans of a municipal utility, such as the Sacramento Municipal Utility District (SMUD), are any more open to public scrutiny than are those of an Investor-Owned Utility (IOU). SMUD is nominally run by a five-man board of directors, elected to terms of four years. Their twice-monthly board meetings are open to the public, and any purchase involving more than

$4,000, and any policy decision, must be approved publicly at these meetings. However, a siting decision would probably not reach the board in public meeting until the end of the option period when the land was to be purchased. At this point both the IOU's and the municipals usually announce the acquisition to the press anyway. A number of people working for utilities and the State point out that the municipal utility in Los Angeles (Department of Water and Power) perhaps is more close-mouthed about its plans than any IOU. In fact, according to a reliable state official, it is currently considering a site for a nuclear power plant within Camp Pendleton, a fact yet to be revealed to the public.

The rights to be balanced are the public's right to know what specific sites are being considered for power plants, versus the utility's right to negotiate for land in private for the sake of speed and economy (which the utility also feels is in the public interest). At present, the latter is preeminent. The results of such a policy, however, frequently have left a bad taste. In Santa Cruz there were rumors for months that PG&E was cosidering building a power plant in Davenport. It took an ad in the local paper by a candidate opposed to the siting to inform the citizenry. Only after the ad was published did the utility hold a press conference to reveal its plans (16). Perhaps as a result of the secrecy, there is a substantial citizens group in Santa Cruz vowing to fight the plant to the end.

At least until an option has been taken on the land under consideration, utility policy is the old adage, "No news is good news." Only a reporter with intimate knowledge of utility plans and the nose of a private detective could get the story.

IV. Local Government

With an option to purchase in hand, the utility next might approach the county board of supervisors with jurisdiction over the parcel and request approval from the county planning and zoning departments for construction of a nuclear power plant. Then again, the utility might not. Both PG&E and SMUD assert that county officials have no legal authority over them. SMUD points to Chapter 6, Article 1, SEction 12703 of the Municipal Utility District Act, which states that in the proceedings, venue and trial relative to the exercise of the right of eminent domain, "the district has all the rights, powers and privileges of an incorporated city and all rights, powers, and privileges conferred in this division." PG&E feels that, at present, the PUC wields absolute authority over its affairs at the local and state level, and if the PUC approves construction on a particular site, the county must acquiesce.

In the siting of its Rancho Seco nuclear power plant in Sacramento County, 25 miles southeast of the City of Sacramento, SMUD did not consult with county planning officials. Says Earl Fraser, Planning Director for Sacramento County, "We would have appreciated working more closely with SMUD on the siting, since we had just adopted a master plan for the Southeast area of the county where the plant is located. They did advise us of their plans, but they did what they wanted to without consulting us." Fraser called it a "poor job of interagency relations" and would like to see all districts and municipalities become more conscious of one another (17). Verna Stetler, clerk for the County Planning Department, echoed Fraser's feelings and stated that the utility "was too big for us to take on." (18)

PG&E's policy has been more conciliatory. Realizing that most county boards of supervisors are delighted to have the utility build a plant in their area because of the increased revenue it will bring and the chance to make the county grow, PG&E has made it a policy to acquire all the necessary use permits even though it does not believe it legally needs them. In years past PG&E has indeed found local boards most cooperative. Concerning the attempt by the utility to site a plant at Bodega Head from 1958 to 1964, Sonoma County Harbor Commission Chairman Robert M. Harkness said, "The job of government is to create the proper environment to attract private enterprise."(19).The Sonoma County Board of Supervisors was most cooperative with PG&E, going so far as to recommend against public hearings on the utility's plans for the site. Similarly, the Boards in Mendocino and Solano Counties approved PG&E plans for nuclear plants at Pt. Arena and Collinsville.

In Santa Cruz, however, given the different political climate in which the utility must now work, there is some doubt as to whether that county's board will approve construction of a nuclear power plant at Davenport. According to Supervisor Phil Harry, the board could split 3-2 either way, depending on the nature of the utility's proposal (20). What would happen if the utility came to the county and was rebuffed? No one seems to know. Harry asked a PG&E official that question and did not receive an answer. At present it is in doubt as to whether the utility will risk approaching the county.

At stake is the earliest, official public hearing on the utility's plans. A public hearing must be held by the Board of Supervisors before zoning can be changed. At this early stage in the site development, it is a hearing the utilities would rather skirt, and it is an excellent news peg for the press to jump into the siting issue and nuclear power controversy while there is still time to change some minds.

The amount of control local officials should be afforded in the siting procedure is a hotly debated question. Recently Southern California Edison applied to the PUC for a certificate of public convenience and necessity to construct a fossil fuel plant at Huntington Beach in Orange County. The PUC gave its approval over the protest of the Orange County Air Pollution Control District, which felt that the lungs of the County's residents could not bear another fossil fuel plant in that area. The PUC argued that it had exclusive control over siting and that the county board could not overrule it. The case (*Orange County Air Pollution Control District v. PUC*, S.F. No. 22766) was decided by the Supreme Court of the State of California, May 26, 1971. The court found against the PUC and in favor of the local air resources board, but it did not settle the preemption question beyond this specific case. Thus, there is still confusion over the jurisdiction of local officials in siting – and they will likely be solved by legislation.

The utilities would like to be free of all local control. This is the thrust of their one-stop shopping legislation. What they most want to avoid is a local referendum on construction of a nuclear power plant, such as occurred in Eugene, Oregon, in May, 1970, when citizens there voted to stop construction. The utilities claim, with much justification, that electric power is at least a regional need and deserves state planning. Tradition boundaries do not make sense when applied to the State's power needs. The utilities are not keen on conforming to regional land use plans, either. They have already gone on record as seeking exemption from having to abide by any master coastal zoning plan which the state may devise (21).

But local officials feel, also with much justification, that *they* must live with the patterns of industrial development that a new power plant would occasion, and they cannot see the wisdom in permitting state officials, insulated from the voters living near the plant, to make these decisions over local protests. Utility officials have said repeatedly that they would not go ahead with a site if there was significant local protest. That remains to be tested at Santa Cruz, or in the courts. The Nixon bill and the bills written by California's public and private utilities settle the matter by taking away local control and establishing a state power plant siting committee as the first step in the siting procedure.

From the access to information viewpoint, it is clear that early site hearings at the local level would be valuable. As will be made clear, the first mandatory public hearing on a site may not come until many months after the land has been purchased, when the utility already has a significant investment in the site and is reluctant to back off. A public hearing before purchase of any land is essential.

V. The State Power Plant Siting Committee

One of the lessons the environmentalists within the State Resources Agency learned from the Bodega Head controversy was that no one body was responsible for approving sites on environmental grounds. The PUC, wholly without environmental expertise, was concerned only that the plant was really needed, and that it was being built economically; the AEC was concerned only that the plant be radiologically safe to operate. But no agency was watching out for the impact of the plant on the air, water and land around it, independent of radiologic considerations. Many state governments still do not recognize this oversight, and only recently has the President addressed himself to the notion of environmental protection in plant siting. As is often true, California was about five years ahead of the rest of the nation.

Concerned about this problem, Governor Edmund G. Brown created by executive order, on June 30, 1965, the Power Plant Siting Committee. The ten members of the Committee are the heads (or their delegates) of the following departments within the Resources Agency (the name of the current member is indicated in parenthesis): Department of Conservation (Jim Koenig); Department of Fish and Game (Chet Hart); Department of Navigation and Ocean Resources (John Habel); Department of Parks and Recreation (James Warren); Department of Water Resources (Donat Brice); Air Resources Board (George Taylor); State Water Resources Control Board (Ray Dunham); Department of Public Health (Amasa Cornish); and State Lands Commission (Francois Uzes). The tenth member is Chairman Paul Clifton, representative of Norman B. Livermore, Jr., Secretary for Resources and political appointee of Governor Ronald Reagan.

The State of California Policy on Thermal Power Plants, adopted June 30, 1965 and revised March 12, 1969, makes clear the duties of this Committee:

> It is the policy of the State of California to ensure that the location and operation of thermal power plants will enhance the public benefits and protect against or minimize adverse effects on the public, on the ecology of the land and its wildlife, and on the ecology of State waters and their aquatic life. Also, the public's opportunity to enjoy the material, physical and aesthetic benefits of these resources shall be preserved to the greatest extent feasible . . .

> To ensure implementation of the State of California policy a committee called the State of California Power Plant Siting Committee has been established. Among its functions is the review of proposed power plant sites throughout the State as to their conformance with this policy . . .
>
> Individual members of the committee are delegated the authoirity and responsibility, by their respective department directors or board executive officers, for reviewing proposed power plant sites, for consulting with all concerned parties within their respective departments or boards on each proposed site, for seeking resolution of conflicts at whatever level of management required, for keeping the department director or board executive officer informed of the status of siting actions, and finally, for communicating in writing the comments, conclusions, stipulations and official position of the department or board relative to each proposed site . . .
>
> It should be clearly understood that a site may be selected and approved long before many of the details of plant design and operation are firmly established. Site approval by the State of California Power Plant Siting Committee need only recognize the necessity of developing said details within the framework of the overall quality and integrity of the natural environment . . . prior to operation of the plant (22).

Although it is the most important watchdog over the environment in the siting procedure, the Power Plant Siting Committee has no official legal status. The utilities need not approach it for approval of a site if they so choose, and any contact between utility and Committee is strictly voluntary. Despite this, all the major utilities in the state, with the exception of the Los Angeles Department of Water and Power, *do* approach the Committee to sign an agreement for each site. In the agreement the utility agrees to follow certain procedures in the construction of the plant, consult with the Committee or specific Departments about problems as they arise in construction, undertake certain ecologic studies, provide recreational facilities for the public at the plant site, and so on. In return for these concessions, the Resources Agency, through its agent the Power Plant Siting Committee, agrees not to oppose the utility as it seeks other licenses and certificates (from the PUC or AEC, for example) later on in the siting procedure. Although the agreement is voluntary, it has the legal status of a contract once it has been signed by Livermore and the utility representative, and it puts the state on record as approving a specific site. The utilities have determined that it is important from a public relations and tactical perspective to have such an arrangement, and it has become the first important stop in the siting procedure. The signing of the agreement is the earliest public announcement by a utility of its intentions.

From six to eighteen months of research and negotiation between members of the Committee and utility engineers and consultants goes into an agreement. Each member of the Committee requests different materials from the utility on which to base his decision on the suitability of the site and the terms to be written into the agreement. The State Lands Commission, for example, concerned with the use made of tide and submerged lands adjacent to the site, will request information from the utility on the effects of construction on the boundary between the uplands owned by the utility and the publicly owned tidelands and submerged lands (23). The State Water Resources Control Board will ask the utility for a recon-

naissance study of the water around the plant. All such studies are paid for and executed by the utility or its consultants. The state does not at present have the money or the manpower to do them independently (24). There is mixed opinion about the quality of material provided by the utilities in these studies.

Once the initial data are in and the individual departments have formulated positions on the site, negotiations begin with the utility in which dissenting agencies are pacified and a general accord reached. There are no public hearings in which interested parties or conservation groups can provide input to the Committee before the agreement is signed. Committee Chairman Paul Clifton believes the utilities would be against public hearings because they would slow up what they feel is already a slow procedure (25). He maintained that the utility-Committee meetings which the agreement is hammered out are open to the public; but such meetings are not announced in advance, thus the public is never present (26). According to provisions of the Brown Act, such meetings need *not* be open to the public as long as the Power Plant Siting Committee is an unofficial body. One former member of the Committee, James Trout of the State Lands Commission, likes the flexible, private nature of the meetings, and feels that if the public were present, many agency representatives would be afraid to speak their minds honestly about a site. For this reason he opposed the Briggs Bill (AB 818) of the 1970 session which would have given legal status to the State Power Plant Siting Committee and would have forced all utilities to secure an agreement on environmental suitability of a site. He did not want to see the negotiations opened to the public (27).

While there are no public hearings or open meetings, it was the unanimous opinion of the Committee members, from Clifton on down, that any information received from the utility on which their decision is based *is* open to the public. This puts the burden on the public to determine when negotiations on an agreement have begun (there is no announcement of this), and whom should be approached for utility material. Apparently, the public and press have not in the past availed themselves of this opportnity for an early look at the utility studies. It is possible that Clifton and the Committee members, under pressure from the utility and the Governor, might become less cooperative in opening up this information if an actual demand for it arises; it seems likely that as long as the Committee is unofficial and the agreement voluntary, the California Public Records Act would probably not cover the utility reports.

The thrust of the utility bills and the Nixon legislation is to make official the role of the State Power Plant Siting Committee, or some similar body with a few public members (although the utilities are opposed to public members on grounds that the state officials represent the public interest) (28). It is likely that the Committee will have official status within a year or two. The trade-off will be removal of all siting authority at the local level. A mandatory public hearing on environmental matters will probably be a part of the new scheme. These steps may help the public and press follow utility plans more closely than at present. The current situation, involving an unofficial committee which is in political fealty to a governor sympathetic to utility interests; with small staff and little money for independent investigation of the utilities' environmental claims; which holds neither public hearings nor open meetings; yet which has the power to sign an agreement binding the Resources Agency not to oppose the utility on environmental grounds, is not in the public interest.

Only a Power Plant Siting Committee with provision for public members, which conducts a site review *before* the utility has made any purchase of land – a site review with public hearings and open meetings – should be substituted for the present system. Such a Committee must have adequate staff and money to conduct independent investigations, and the power to say "yes" or "no" to a utility on a specific site.

The present Committee has yet to deny an agreement on a site for a nuclear facility to a utility. The most important environmental decisions are being made behind closed doors.

VI. Other State Agencies with Pre-Construction Jurisdiction

While the State Lands Commission, State Water Resources Control Board, and the State Department of Public Health take part in the negotiations which lead to an agreement (all agreements are unanimous – there are no minority reports), they have other jurisdiction over the utilities which is not limited by the agreement.

A. State Lands Commission

For any coastal site, the State Lands Commission must issue a lease to the utility for occupation of the tideland. Issuance of the lease is the greatest power the State Lands Commission wields in the siting procedure. Without the lease the utility cannot proceed with construction of the plant. Formal action on the lease takes place in a public proceeding before the Commission sometime after signing of the informal agreement. The proceeding may be adversary in nature and members of the public may appear and challenge the granting of the lease. (The most famous recent example of public intervention in this process came when the Commission was considering granting leases to the oil companies to resume drilling in the Santa Barbara Channel. The Sierra Club was able to hold up the lease for PG&E's Diablo Canyon nuclear power plant for some months. All were finally granted.) The documents submitted to the Commission in support of the lease application are also public.

Ten times each year the Commission issues a summary agenda of its actions to the press and the legislature. According to Commission staff member James Trout, press coverage of Commission activities varies from one sleepy reporter to a full array of television cameras on the off-shore drilling question (29).

B. State Water Resources Control Board

According to the Federal Water Quality Improvement Act of 1970, which became effective April 13, 1970, a utility must provide to the AEC certification that a proposed power plant will not violate state water quality standards. For California, this certification must come from the Regional Water Quality Control Board – the State is divided into nine regions – with jurisdiction over the proposed plant. Again, after the signing of the agreement with the State Power Plant Siting Committee, the appropriate Regional Board holds a public hearing at which the utility presents preliminary design data on the plant and a description of the plant's discharge. The Regional Board must certify that the thermal discharge will not violate the standards set by the State Water Resources Control Board. The documents involved in this hearing are public.

In years past utilities have approached this hearing locked into certain design specifications and have pressured the board into approving utility plans without modification on grounds of prior investment. (This is the strongest argument for early and continuous public review of utility siting plans.) For the nuclear plant at San Onofre, Southern California Edison and San Diego Gas and Electric had already ordered the equipment for the plant and were unwilling to make modifications for the Board. They charged that the siting procedure is so drawn out that in order to meet the State's growing power needs it was necessary to order the equipment in advance of the hearing (30). Such arguments, of course, make the hearings meaningless. According to some observers, the utilities are now being more cooperative with the Boards, largely because the question of thermal standards for the discharge (the most serious water pollution problem for nuclear power plants) is so crucial to utility economics. Under intense political pressure, the State Water Resources Control Board adopted new thermal standards in January 1971, which the Federal Government's Environmental Protection Agency must study to see if it will adopt them as Federal standards, also. Now that the Federal Government has entered the water standards picture, utilities are taking the Regional Boards and their certification more seriously.

If a utility has made an end run around local officials, the public hearings held by the State Lands Commission and the Regional Water Quality Control Board are the *first* two official public hearings in the siting procedure. These hearings are likely to be held up to two years or more after the time the utility first entered into negotiation with the State Power Plant Siting Committee. And that might be three years since the utility first began to develop a scientific profile of the site. Clearly, the utility has a substantial investment in time and money when these hearings roll around.

C. **State Department of Public Health**

At this stage a number of other less important state actions take place. In the realm of the unofficial, the State Department of Public Health enters into a monitoring agreement with the utility. This is generally signed some four or five years before the plant is ready to go into operation. While the AEC is concerned with setting radiologic standards inside the plant, it assumes that careful application of these standards will result in little or no damage to the environment outside the plant. The monitoring of the State Department of Public Health is essentially a check on this theory. The agreement signed with the utility specifies what that procedure will be. Usually monitoring starts two years before the plant begins operation so that a baseline can be established. The utility or its paid consultants measure the radiation build-up at some thirty stations in the vicinity of the plant. The Department of Public Health replicates the utility data once a year. The monitoring agreement itself is public, as are the monitoring reports which accumulate once the plant is in operation (31).

Depending on the requirements of the site, the utility may also have to approach the State Department of Water Resources for a permit to construct a dam on State waters; or the Department of Parks and Recreation for an easement across state-owned beaches and shores. Once the plant is ready to operate, the utility must secure a permit from the State Department of Industrial Relations, Division of Industrial

Safety, to operate the equipment inside the nuclear power plant. But these other state actions are unimportant in the overall siting procedure in comparison with the significance of the unofficial agreement with the Power Plant Siting Committee, the permit from the State Lands Commission, and the certification from the regional water quality control board. Once all of this is in order, the utility (if it is an IOU) is ready to approach the last state hurdle: the State Public Utilities Commission.

VII. The Public Utilities Commission

The California Public Utilities Commission is, in theory, the public's most significant point of access to the utility decision-making process. Before an IOU can build a plant or lay transmission lines, it must secure from the PUC a certificate of public convenience and necessity. This requires the utility to submit detailed information about the plant to the Commission all of which is available to the public; and it demands a hearing in which the public may play a significant role. Further, the 1911 act which created the PUC states that the Commission must act in the public interest, giving the Commissioners broad powers to consider whatever information they feel is important and in the public interest in determining the disposition of the utility application. A PG&E spokesman has called the PUC "the protector of the public . . . with responsibility to make sure the public is represented in all its viewpoints." (32)

While the PUC could, if it so chose, investigate the environmental impact of proposed plants and transmission lines, it has left such matters to the State Power Plant Siting Committee, whose agreement with the utility the PUC depends upon heavily. The PUC does not have the scientific expertise at the present time to evaluate environmental impact, and the Commission's budget is being constructed rather than expanded. According to one of the PUC's most articulate spokesmen, Utilities Division Engineer Walter Cavagnaro, "the Commission basically determines if the plant is really needed, based on projected power needs, and whether the proposed location of the plant is adequate to those needs. Occasionally some questions of radiologic safety are considered, but those are really the province of the AEC." (33) The PUC has no environmental specialist on the staff and is essentially an aggregation of engineers and attorneys. The major concern is with the dollar-costs of power.

Some time after the utility has signed the agreement with the Power Plant Siting Committee, it approaches the PUC for pre-filing meetings; through these the utility learns what it must provide the PUC staff in its certificate application. These informal exchanges help both sides prepare their cases and make sure that the public record is thorough. As staff level meetings, they are *not* open to the public by provisions of the Brown Act. (As stated in the previous chapter, the regular deliberative sessions of the Commissioners are also closed to the public because they are considered in the same light as judges meeting in chambers.)

At least twelve months prior to the date a decision is required from the Commission, the utility must file its application for the certificate of public convenience and necessity. It must include a statement of why the proposed facility is necessary; safety and reliability information; estimated cost information; a schedule showing the program for design, material acquisition, construction and testing, and operating

dates; available site information, such as geological, ecological, seismic, water supply, population, and other data; a description of the provisions for the mitigation of air and water pollution problems; a list of the governmental agencies from which various approvals have already been obtained; and more (34). Public notice of the filing of the application must be made within ten days through publication of a notice in a general circulation newspaper in the county in which the proposed facility will be located.

The entire application is open to the public, but the PUC has neither the manpower nor the inclination to provide assistance in understanding it. To illustrate this point, former PUC Commissioner A. W. Gatov recalled that when he was a Federal Maritime Commissioner, Drew Pearson was looking into a ship sale scandal and requested to see all the minutes of Commission meetings from 1945 to 1950. Pearson sent one of his researchers to do the work, and Gatov provided the minutes, stacked up in piles in a conference room. He soon received a call from Pearson, who complained that he only wanted the minutes pertaining to ship sale scandals. Gatov told him that it was his job to weed out the useful material. The public is in the same position with regard to the utility applications. Gatov emphasized that much of the information the Commission receives from the state's IOU's is public (35).

(Unrelated to the application but apropos of utilities and access to information, there is much basic data which many state commissions themselves cannot get, such as how much the utility earns for each share of stock outstanding; interest costs on long-term debt; a detailed breakdown of how funds collected from ratepayers are spent; and ownership. Montana Senator Lee Metcalf has regularly introduced legislation which would compel utilities to provide state commissions with this information, but thus far it has been defeated by the utility lobby (36).)

The public hearing on the application is held as near as possible to the plant site, although if the hearing is particularly long, a portion of it may be held in San Francisco, seat of the PUC. The hearing is run by an examiner, whose job it is to develop a full record. He writes a decision based on the testimony, which is submitted to the presiding Commissioner. Three of the five Commissioners must assent to the decision of the examiner for it to become final. At present, any member of the public may contribute testimony or cross-examine a witness during the proceedings. The PUC provides a team of staff people who assist individuals in making statements for the record. A member of the public need only show up at the hearing and fill out an appearance form to participate. The impact of the testimony, of course, depends on the logic of the presentation. But former Commissioner Gatov notes that a real public outcry at a hearing has impact, because that is the only way the Commissioners "can judge what is going on in a community." (37)

In general the utility must allow a year to obtain the certificate for a new site, six months for permission to add a second or third unit to an already operational site.

The PUC has *never* turned down a request for a certificate of public convenience and necessity for a nuclear power plant. Part of the reason is in the nature of American regulatory commissions: the PUC is as much a creature of the utilities it must regulate as the FCC is of the broadcast industry. The PUC's Cavagnaro admits that for a utility to suffer a reversal at this stage of the siting procedure "would be a great

shock." (38). Furthermore, since Ronald Reagan became Governor of the State, the once-proud tradition of the PUC as a true public defender (which the utilities still claim to be the case) has been sabotaged. The Commission is now entirely composed of Reagan appointees. Commissioner Fred P. Morrisey is a former paid consultant for Pacific Telephone, and was recommended to Governor Reagan by a group of utility company attorneys (39). The current chairman, J. P. Vukasin, Jr., is on record as stating "I question the propriety of a regulatory agency such as this commission substituting its judgment for that of utility management in this unique and complicated field (tax accounting)." (40) That "judgment," of course, is the responsibility of the Commission.

Chairman Vukasin has begun a system of rotation whereby experts in one kind of utility regulation will be moved to a new field. This has been done to bring in fresh ideas from new faces. In reality, the near-total staff rotation will make it difficult for the conscientious PUC staff to match wits with the utility experts (in what has always been an unequal battle between the understaffed PUC and the rich utilities). An angry letter to Vukasin from 33 staffers makes clear the effect the rotation system will have on protecting the public interest:

> Utility regulation can be effective only if the regulator is able to know and understand the complexities of the utility's operations. Some of these utilities are among the largest corporations in California or even in the United States.
>
> We are proud to be a part of this commission, a nationally recognized leader in regulatory affairs. Your staff rotation plan, we are convinced, will drastically change this status and seriously reduce the quality of our service to the commission and to the public." (41)

Of equal import to the public, particularly its right to testify at public hearings, is Vukasin's recommendation of December, 1970, that a requirement for participation be retention of counsel, and that only attorneys will be able to cross examine witnesses. This proposal came to Vukasin from a Bar Association Subcommittee of utility lawyers, principally members of the firm Pillsbury, Madison and Sutro, which represents Pacific Telephone and Telegraph Company. In a hearing procedure already dominated by scores of well-trained, well-paid utility lawyers, such a rule would make it difficult for a citizen to state his case against a utility to the Commission. It was a bold attempt to cut the public out of the hearing process. The public outcry which greeted this proposal led to its rejection by the whole Commission. But it indicates the nature of the Chairman's thinking; it is obvious that he is little concerned with facilitating public participation in the decision-making process. California State Senators Alfred Alquist and George Moscone (both Democrats) have already investigated and criticized the performance of this Commission.

For the press and public, the PUC represents a point at which to gain access to some detailed information on the proposed plant available in the utility's application (although it will take an informed person to sort out the useful from the useless). At present, the PUC also offers a second stage of public hearings on the site so that private citizens and conservation groups can register their feelings. It is also a natural news peg for the media to investigate the plant site and report on the nuclear dilemma. But the

chances of the public, the press or the PUC staff effecting major changes in utility plans at this stage are practically nil: about as likely as the FCC taking a broadcast license away from a network-affiliated television station.

VIII. The Atomic Energy Commission

By the time the utility has secured the certificate of public convenience and necessity, a minimum of two years, and probably closer to three, have passed since the opening of negotiations with the Power Plant Siting Committee – perhaps four years since the utility first took an option to buy the property. The final two regulatory hurdles of consequence, the construction permit and the operating license, come from the AEC, and they add another three years, at least, to the siting procedure. (This is the reason utility officials chafe as an "obstructionist" public seeks further delays.)

Before the Federal Government in 1969 became actively interested in protecting the environment, the AEC's responsibility was uncomplicated; it was to review the design specifications of the plant and insure that it would operate safely. This is still the AEC's most important function. (It should be noted for the record that the AEC is both promoter and regulator of nuclear power plants. It is responsible for much of the research that has made such power plants a reality, and it has been under pressure from the Joint Committee on Atomic Energy to get this part of the "Atoms for Peace" program underway. The Commission does not so much say "yes" or "no" to a utility as it works with management until the plant design is acceptable.)

In applying for the construction permit, the utility submits a massive Preliminary Safety Analysis Report (SMUD's PSAR for the Rancho Seco site was five volumes, each three inches thick) which describes and analyzes the characteristics of the site, and explains the technical and design features of the plant and their relation to safety. The AEC regulatory staff probes for potential problem areas, asks for additional information, raises questions about the design, and tests the assumptions about safety. After the AEC staff review, the PSAR is reviewed by the independent Advisory Committee on Reactor Safeguards, which also must approve the safety of the plant. These two groups do not always agree. The design for the Bodega Head site was approved by one, and found unsafe in case of earthquake by the other, and PG&E withdrew the application as a result.

After these reviews, there is a mandatory public hearing near the plant site, conducted by an atomic safety and licensing board, consisting of two technical members and a lawyer. The utility, the AEC staff, and the public (members whose interests are affected) may call witnesses and cross-examine. The rest of the public may express its views according to a policy of "limited appearances." (42)

Only after these reviews will the Commission issue the construction license. Because of the evolving nature of nuclear power plant technology, the Commission is likely to permit a utility to solve some problems in construction. This has been a sore point with many AEC and power plant critics, who believe such "provisional" construction permits give the utility license to solve serious safety problems as it sees fit. The AEC review however, does seem to be comprehensive. To receive an operating license, the utility must

go through essentially the same procedure as for the construction permit, in which the AEC staff and the Advisory Committee on Reactor Safeguards examine a Final Safety Analysis Report. At this stage the AEC will hold a public hearing only if an outside group can show good cause why such a hearing is necessary – such as if new safety problems have arisen in light of additional research since the beginning of construction. At this point the AEC and the utility are least tolerant of delay. The plant is ready for operation, and according to the utility, is needed to provide power in its area of service. Delays can mean a cost of $50,000 to $100,000 a day. Nevertheless, citizens' groups have held up operation of a number of nuclear power plants at this stage either through requested hearings or a court order.

To the AEC's credit, all documents which the utility must submit for the construction permit and operating license are public. The AEC staff evaluation of the plant is public. The entire file is available both in Washington and at a place near the proposed site. The AEC's Assistant Director of Public Relations, Joe Fouchard, emphasizes that the nuclear power program is totally unclassified. He admits that although the AEC was born in secrecy and there is still much secrecy surrounding the weapons testing program, this is not the case for nuclear power (43). In support, California Representative John E. Moss, Past Chairman of the House Subcommittee on Foreign Operations and Government Information, which acts as the freedom of information watchdog, states that only one or two complaints about AEC secrecy come to his attention each year from the public. In this regard he termed it one of the best agencies in Washington, an image at odds with the traditional picture of the AEC (44).

The only conflict over access to information which has arisen at this stage of the siting procedure concerns the AEC's compliance inspection reports. These are reports filed by AEC investigators which state what they found wrong with the safety of the proposed plant in their independent research. Potential intervenors at hearings would like access to this information. In the past it has not been made available, although enforcement action taken on the basis of the reports has been made public. The feeling was that these reports were internal to the AEC and that making them public could hurt the inspection function of the Commission. Fouchard contends that the AEC is changing its position on the compliance inspection reports, and that with some excisions (at the behest of equipment manufacturers who are concerned about competition and a bad public image) they will be available in the future (45). This bears close watching, as such reports could be valuable to the public. Indeed, they are probably more valuable to the opponents of a plant and to the press than is the utility's own PSAR.

This was the limit of the AEC's responsibility before the environment became a political issue. Since passage in 1969 of the National Environmental Policy Act, *every* Federal agency issuing a permit, license or funds for a project must make a preliminary assessment to determine if the project will have some impact on the environment. If the determination is positive, the agency is responsible for drafting an Environmental Impact Report (known as a "102" statement, for the section of the Act requiring it) which discusses:

1) The environmental impact of the proposed action,

2) Any adverse environmental effects which cannot be avoided should the proposal be implemented,

3) Alternatives to the proposed action,

4) The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

5) Any irreversible and irretrievable commitments on resources which would be involved in the proposed action should it be implemented.

In the case of licensing nuclear power plants, the AEC does not bother with an assessment. It must issue a 102 statement for each plant.

The AEC requests from the utility a document entitled "Applicant's Environmental Report – Construction Permit Stage." Originally, the Commission wanted to circulate this report to the various federal, state and local agencies with environmental expertise for comment, but the President's Council on Environmental Quality (which acts in an advisory capacity to the President) prevailed on the AEC to write its own draft statement based on the report. Agencies which receive copies of the draft are given a fixed period in which to comment, and then the AEC must write a final draft 102 statement in which it incorporates the comments and states its own view on the environmental impact of the plant. Before the construction permit can be issued, this final statement is circulated to other agencies, most importantly the Council on Environmental Quality, which might, if it disagrees with the AEC assessment, recommend Presidential intervention. The AEC must issue both draft and final 102's at the construction permit and operating license stages.

The purpose of all this is to force all federal agencies to consider environmental impact in all their decisions. The goal of the Council on Environmental Quality is that this procedure become internalized in each agency so that it will not have to police the Federal Government forever on environmental matters. And the best way to internalize the environmental ethic is to require these written statements. The AEC has recently hired new personnel to evaluate the utility environmental reports and prepare the 102's. (But note that, as is true throughout the siting procedure, the major burden of providing environmental information rests with the utility.)

At first the AEC was unwilling to make both the draft and final 102's public, but under pressure from the Council on Environmental Quality they have agreed to do so. The entire file of utility reports, agency comments, and AEC 102's is public.

It now takes at least a year and one-half for the AEC to act on the construction permit application, and two years to grant the operating license. More and more hearings are being contested. As a result, the AEC is pressing for legislation which would call for an early site hearing to be held either by the Commission or a state Power Plant Siting Committee, at which all environmental matters would be considered. If

the site were approved at this stage, the AEC would not have to consider environmental matters at the construction permit stage. Further, the public hearing at the construction permit stage, at which environmental matters now can be introduced, would be limited to questions of radiologic safety, and there would be *no* public hearing at the operating license stage. This would clearly streamline the procedure and speed up the licensing process, but it would be a blow to the groups battling the siting of nuclear power plants. It would limit further the public's participation in the decisionmaking process and reduce the amount of information on environmental impact available to the press.

(AEC Commissioner James T. Ramey points out that the public has another entry to the siting procedure in the rulemaking process in which general safety criteria are set. The Commission develops a proposed rule, publishes it for the purpose of receiving public comment, reconsiders the rule, and then reaches a decision. Ramey notes that many groups and individuals have availed themselves of the opportunity to comment on proposed rules (46).)

The AEC's public hearings, 102 statements and compliance inspection reports are valuable resources for the press and public, although, again, one must know what one is after to make use of these materials. The AEC and the utilities feel that perhaps there is too much public participation and potential for harassment at this stage. However, it must be recognized that if utility plans have proceeded to the construction permit stage, it is most unlikely that the plant will not eventually be built and operated. The public can only become involved negatively at this stage. The time for positive action was two or three years earlier.

IX. Other Federal Agencies with Pre-Operational Jurisdiction

Just as at the state level, a number of other federal agencies have minor roles to perform complementing the work of the AEC. The Federal Aviation Administration must issue a permit for any elevated structure at the plant site, such as a stack, which might interfere with air traffic. If the plant is to be built on federal land, a permit is required from the Department of the Interior's Bureau of Land Management. If the plant or its transmission lines are to be built on public forest lands, the utility must have a permit from the Department of Agriculture.

A. Army Corps of Engineers

At the end of 1970 it was announced by the Nixon Administration that all persons pouring waste materials into the nation's waters would have to secure a permit from the Army Corps of Engineers. While some critics have charged that this will simply be a license for industry to pollute, it will be possible, if the Nixon Administration is serious about cleaning up the environment, to more effectively monitor and regulate what is being poured into the water. To date, it has not been determined whether the Army Corps will have jurisdiction over discharges from nuclear power plants, but this bears watching as another possible handle for those opposed to the plants.

B. The CEQ and EPA

Finally, we come to the two new Nixon creations for cleaning up the environment: the Council on Environmental Quality (CEQ) and the Environmental Protection Agency (EPA). CEQ receives "102" statements from all federal agencies and acts as a behind-the-scenes broker, putting together agency comments on the environmental impact of various projects, and then advising the agency of origin on the Administration's position. "Its actions must be kept secret," says staff member Bill Matuszeski. "When there is a controversial decision to be made, with many delicate negotiations to work out and much give and take among the agencies, we feel we must keep our role secret to preserve our freedom to maneuver. It would not be in the public interest to have all our discussions with the agencies made public." (47) How much of a yes/no authority the CEQ can muster over nuclear power plant siting remains to be seen. But on a hopeful note Matuszeski states that letters from the public on projects with potentially grievous environmental impact are one of the chief ways he and his colleagues at the CEQ know which of the thousands of federal projects and 102 statements to watch. He makes an excellent case for an informed public and an environmentally active local media (48).

The role the new EPA will play is even more mysterious. Two of the agency's five functions (air, water, radiation, pesticides, and solid wastes) bear on power plants: water and radiation. The EPA has taken over the Federal Water Pollution Control Administration. State Water Resources Control Board standards which are adopted by the EPA will also become federal standards with federal muscle behind them. As stated earlier, the AEC must get certification from the appropriate Regional Water Quality and State Water Resources Control Boards in California that the proposed plant will not violate standards. The EPA may gain some control over siting in this way. As yet, it has not been determined what the radiation division will do, except that EPA has taken over the functions of the Federal Radiation Council, a standard-setting group which works closely with the AEC. The radiation division of EPA may also become involved in post-operation monitoring to determine the effects of radiologic pollutants from the plant on the environment. But these decisions have yet to be made by EPA head William Ruckelshaus and the President.

H. Conclusions

1) The volume of information available to the public about the suitability of the proposed power plant site and the safety of the design specifications is substantial: the application filed with the PUC for the certificate of public convenience and necessity; the applications to the AEC for the construction permit and operating license; the AEC's compliance inspections reports; and the draft and final Environmental Impact Reports, to name only the most important. But it takes a knowledgeable member of the public or press to get at this material and interpret it.

2) On actions of an Invester-Owned Utility, the public will receive a minimum of four public hearings, and more likely six or seven. For a municipal utility the public will receive one less hearing, since municipals need not apply to the PUC for a certificate of public convenience and necessity.

3) For both types of utilities, the public hearings and the availability of information come late in the

siting procedure, *after* the utility has invested two or three years and hundreds of thousands of dollars in preparing a site for a plant. By the time the public is given access to the decisionmaking process, the utility is committed to a site by prior investment, and the public can act in a negative, delaying fashion only. There is little or no cooperation between the utility and the public in deciding basic power and siting questions. Nor does there seem to be a willingness on the part of the utility to include the public in a positive way. Utility secrecy until such time as the site has been purchased is testimony to that.

4) Point three is also reflected in the stance of the State Power Plant Siting Committee, the PUC and the AEC, which all must *react* to those sites chosen by the utility. Government does not now, nor does it plan to, share siting responsibility with the utility. It is also obvious, but worth stating nevertheless, that there is no ombudsman-like governmental agency independent of the utility to watch out for the public interest in this matter. The state agencies must depend on the utility for much basic information about the site, and the key state officials involved are under political pressure from a pro-utility Administration and cannot act as free agents; the demise of the PUC has been chronicled earlier; and the role of the AEC as both promoter and regulator of the uses of atomic power makes it ineligible for the role of ombudsman. By default this role falls to the press.

5) Those "official" points of entry for the public to the decisionmaking process – the public hearings – are too few and too late. A municipal utility can avoid a public hearing of consequence until it approaches the AEC for a construction permit. An IOU participates in a public hearing a bit earlier, at the PUC stage. The public should be heard on the suitability of the site before the utility has purchased any land, and before it has made any investment in time or money. Further, a public without information is a public crippled in a hearing procedure. And without accurate information, a public challenge is more likely to be emotional and frivolous.

6) The siting procedure and access to information do not vary considerably from the municipal utility to the IOU. Both types of utilities really run the siting procedure and are responsible for providing most of the basic data. It may be easier under the Brown Act and the California Public Records Act to get some information, after the site has been purchased, directly from a municipal utility than from an IOU; but the government agencies involved in the siting procedure at all levels claim to be cooperative in releasing information they have, often regardless of the utilities' feelings. The problem is that they do not receive word of utility plans early enough, and the Brown Act and California Public Records Act do not help in this regard.

7) At present the best, earliest sources of information for the press and public are the members of the State Power Plant Siting Committee during negotiations with the utility over an agreement. Most members have indicated that they will make available all information they get from the utility during the course of negotiations, and their personal estimates of the site are also valuable. It does not seem, from preliminary investigations, that these people are presently being approached by the press.

8) Since it is likely that the State Power Plant Siting Committee, or a reorganized equivalent, will retain responsibility for the most thorough environmental review of the site, it is very important that this

Committee have public members, that it hold a mandatory public hearing in the vicinity of the site, and that it act before the utility has invested either time or money in a site.

9) As the Danveport, Rancho Seco, Pt. Arena, Diablo Canyon, and other nuclear power plant sitings indicate, the utilities are looking to rural areas without metropolitan papers and large groups of potentially active citizen-opponents. Further, the utilities have tried to circumvent local control over siting wherever possible, and pending legislation indicates that they will receive a legal boost in this effort. This raises the difficult question of whose responsibility it is to cover the siting story, given that the plant may be located 50 miles away from a major city, but the power it will produce is intended for that city's citizens. In addition, the local media and local political figures do not have the resources or power to resist the utility. (See Volume II for some additional light on this point.)

10) On the positive side, it seems that all levels of government impinging on the siting procedure have internalized the goals of the Brown Act, the California Public Records Act, and Federal access legislation. They show a regard for the public's right to know on this issue and are willing to make available information to anyone who knows what questions to ask, and when. Again, the problem is that these agencies do not receive adequate information from the utilities early enough in the siting procedure;

11) Generalizing from just the PG&E and SMUD experiences, it seems that the IOU has not internalized this notion of the public's right to know (nor should it since the freedom of information laws do not apply). The municipal utility is conscious of the public's right to know; yet the procedure is so arranged that a municipal utility can avoid a public hearing for the first three years after a site is chosen. The municipals seem most vulnerable to questioning by the press and public in the very early stages of site selection; but the only instance of a municipal utility building a nuclear plant in California is SMUD at Rancho Seco. If and when the Los Angeles Department of Water and Power decides to build a nuclear power plant, this course of action might be tried.

12) Such public officials as PUC Chairman Vukasin, Joint Committee on Atomic Energy Chairman Chet Holifield and certain PG&E officials have stated that the power plant siting question is too complex for the layman to understand, and that all decisions should be left to the experts. Local control over siting is already in danger of being cut out of the decision-making procedure. If the press does not choose to report this subject, then the decisions will surely be made by the experts alone. This point will also be treated more fully in the next chapter.

13) Given the immense advertising and public relations resources at the command of the utilities and the AEC, and given the impecunious nature of citizen and conservation groups, it seems that unless these groups are funded by the utility users and a People's Counsel created to combat the batteries of utility lawyers, only an alert press can help redress the balance.

14) As the Office of Science and Technology's report *Electric Power and the Environment* makes clear (pp. 55-61, California has a more thorough, open siting procedure than most states in the United States. The question of power plant siting will become more important to increasing numbers of people in the next few years as more electric power is needed. The way the press in California reacts should be of interest to the Nation's news media as a whole.

FOOTNOTES

1. James R. Adams, "Ecological Investigations around Some Thermal Power Stations in California Tidal Waters," *Chesapeake Science*, Vol. 10, No. 3 and 4 (September-December 1969), p. 146.

2. *Ibid.*, p. 153.

3. *Ibid.*, pp. 145-154.

4. Daniel Merriman, "The Calefaction of a River," *Scientific American*, Vol. 222, No. 5 (May 1970), p. 42.

5. *Ibid.*, p. 45, 52.

6. Remarks by AEC Commissioner James T. Ramey before the Atomic Industrial Forum 1970 Annual Conference, Washington, D.C., November 17, 1970. Appendix F.

7. The Energy Policy Staff, Office of Science and Technology, *Considerations Affecting Steam Power Plant Site Selections* (December 1968), p. 5.

8. Report prepared for the Joint Committee on Atomic Development and Space, California Legislature, *Siting Thermal Power Plants in California* (February 15, 1970), p. VIII - 10.

9. California State *Assembly Journal*, August 5, 1969, Regular Session, pp. 7552-7553.

10. *Ibid.*, Appendix 2, p. 1.

11. The Energy Policy Staff, Office of Science and Technology, *Electric Power and the Environment* (August 1970), p. 28.

12. Electric Utility Industry Task Force on Environment, *The Electric Utility Industry and the Environment*, A Report to the Citizens Advisory Committee on Recreation and Natural Beauty (1968), pp. 103-104, Reprinted from *Electrical World*, Dec. 4, 1967.

13. Personal interview at PG&E, February 3, 1971. See Bibliography at the end of this volume for an annotated list of those interviewed.

14. Personal interview with Gene Blanc, February 22, 1971.

15. *Ibid.*

16. Personal interview with Phil Harry, February 22, 1971.

17. Telephone interview with Earl Fraser, January 28, 1971.

18. Telephone interview with Mrs. Vera Stetler, January 28, 1971.

19. David E. Pesonen, "Citizen Atom at the Park," a personal account of the fight to save Bodega Head, p. 8. Quoted from the Santa Rosa *Press-Democrat*, July 24, 1959.

20. Personal interview with Phil Harry, February 22, 1971.

21. Personal interview with Celia Vondermuhll, February 23, 1971.

22. *Siting Thermal Power Plants in California*, Appendix 2, pp. 1-3.

23. Personal interview with James Trout, former State Lands Commission delegate to the State Power Plant Siting Committee.

24. Personal interview with Ray Dunham, State Water Resources Control Board delegate to the State Power Plant Siting Committee.

25. Personal interview with Paul Clifton, January 27, 1971.

26. *Ibid.*

27. Personal interview with James Trout, January 28, 1971.

28. Personal interview with Gene Blanc, February 9, 1971.

29. Personal interview with James Trout, January 28, 1971.

30. Personal interview with Ray Dunham, January 28, 1971.

31. Personal interview with Dr. John Heslop and Amasa Cornish, February 5, 1971. Both are members of the State Department of Public Health, and Cornish is that Department's delegate to the State Power Plant Siting Committee.

32. Personal interview at PG&E, February 3, 1971.

33. Personal interview with Walter Cavagnaro, February 3, 1971.

34. See General Order No. 131, Decision No. 77301, of the Public Utilities Commission of the State of California, pp. 8-9.

35. Personal interview with A. W. Gatov, February 2, 1971.

36. U.S. *Congressional Record*, January 24, 1969.

37. Personal interview with A. W. Gatov, February 2, 1971.

38. Personal interview with Walter Cavagnaro, February 3, 1971.

39. Ivan Sharpe, "Utilities 'Man' on PUC," The San Francisco *Bay Guardian*, February 16, 1968.

40. U.S. *Congressional Record*, December 30, 1970. Statement by Montana Senator Lee Metcalf.

41. *Ibid.*

42. Remarks by Atomic Energy Commissioner James T. Ramey at the International Atomic Energy Agency Symposium on Environmental Aspects of Nuclear Power Plants, United Nations Headquarters, New York City, August 13, 1970, p. 7.

43. Personal interview with J. J. Fouchard, February 11, 1971.

44. Personal interview with Congressman John E. Moss, Febuary 10, 1971.

45. Personal interview with J. J. Fouchard, February 11, 1971.

46. Remarks of AEC Commissioner James T. Ramey, August 13, 1970, pp. 5-6.

47. Telephone interview with Bill Matuszeski, February 10, 1971.

48. *Ibid.*

Chapter Nine

CONCLUSIONS

We began this volume discussing the concept of ecological medicine — that medical perspective of viewing the man in his world. We know that factors beyond the province of traditional medical approaches can have an equally forceful if not greater impact on human health and well being. Consequently, for medicine to continue to relieve human suffering it needs to look beyond traditional boundaries. For ecological medicine to fulfill its role it must make use of the insights provided by numerous disciplines. In this study alone, these have included medicine, biology, ecology, law, economics, sociology, psychology, engineering, politics, and communications.

The broad approach which ecological medicine offers can readily be utilized by the medical profession to benefit humanity. It will have an even greater impact, however, if the people served are able to genuinely have insight into their own welfare, if, for example, they are able to realize the consequences of various governmental actions on their individual lives and are able to actively think about and participate in these public affairs which affect their own health and existence. For people who have completed their formal education, the mass media, and particularly the newspapers, are their primary means of continuing education. Consequently, the newspapers have an obligation toward their reading public, an obligation which is sometimes difficult to discharge because of the unavailability of needed information, because of government or corporate gatekeepers keeping the information hidden from public scrutiny, or because newspapers find themselves caught in a conflict of interest.

In 1947, Robert M. Hutchins, then Chancellor of the University of Chicago, headed the 1947 Commission on Freedom of the Press. In its summary report, *A Free and Responsible Press*, the Commission made five demands upon the press, the first of which requests "a truthful, comprehensive, and intelligent account of the day's events in a context that gives them meaning."

Each word in this first statement of the Commission has relevance to the effective functioning of ecological medicine and to the material we have discussed under its rubric in this volume. It is doubtful that

the voters realized what they were voting for in 1959 and 1960 when they authorized the State Water Project. No one at the time had any inkling of the environmental consequences such a development would have. We are only now gaining insight into these areas, as research, limping along on limited budgets, provides new information. The motives of those who urged the State Water Project's implementation ranged from the most altruistic and idealistic to the most crass. While neither the media can be faulted for not informing the public of likely consequences of the Project, since these were unknown, nor can officials in the State Government be faulted for concealing information, since it did not exist. a thorough job of investigative reporting could have uncovered the sticky history of water development in the State, from Los Angeles' Owens Valley development nearly one hundred years ago and the birth of the Central Valley Project in 1931.

This history clearly shows that once the Central Valley Project passed into federal hands in 1935 the large land holders, such as Southern Pacific Railroad, United Fruit, and numerous large banking houses, were upset with the federal regulation limiting the amount of water they could take to only that amount which would irrigate 160 acres. While this 160-acre limitation was never enforced rigidly, the large land-holders tried various end-run approaches, none of which worked. This was one large factor behind their advocacy of state control of water deliveries to the Central Valley. The Feather River project, perhaps unidealistically born in 1951, was the vehicle through which the large land interests would escape the federal restriction. During the Fifties the development enlarged into the present State Water Project.

From the start the project has been criticized as economically unsound. This original claim has more than been born out as total costs for completion of the project have skyrocketed and as the cost per acre-foot of water to Central Valley users has soared to $27.50 per acre-foot (compared with $2.50 to $3.50 for federal Central Valley Project water). Because of the tremendous cost of transporting the water over the Tehachapi Mountains in southern California, the presently estimated cost of water to Los Angeles stands at $80 per acre-foot. Expensive as this is, the City of the Angels will have to settle for it. At their present growth rate a severe water shortage will be imminent without this added water input.

There is something extremely paradoxical involved in shipping water out of the exceptionally fertile and agriculturally productive Delta region to bring new lands in the Central Valley into production. Such diversion will certainly affect the quality of water available in the Delta region and the change in water quality will probably affect crops. The paradox further increases since the Federal Government is currently paying subsidies to many Central Valley farmers *not* to raise crops on *already* irrigated fields. The precise motivations and political realities behind such water project development are far from clear and warrant closer scrutiny.

The State Department of Water Resources has evolved into an unusual position over the past 15 years. It is planner, distributor, and packager of water resources. In selling state waters the planners have become salesmen and the agency is becoming more customer-oriented, rather than watchdogging the interests of the people of the State of California.

A major stated assumption behind the need for the State Water Project portions of the California

Water Plan is the growth of the South Coastal Hydrologic Region, which includes the Los Angeles Basin. During the four years which intervened between *Bulletin 160-66* and *Bulletin 160-70* DWR changed some basic assumptions and attitudes. They assume that the rate of population growth in Los Angeles will decrease and that the per capita water demand will begin to level off.

The shift in attitude was reflected in the last chapter of *Bulletin 160-70* which discussed various alternatives for establishing population redistributions, consistent with air, land, and water resource availability, rather than continuing to populate already jammed metropolitan areas. This is an important step in the right direction, for without question, water is a major limiting resource in any city's continued growth. Without water the city population will not be able to increase. When considering Los Angeles this is particularly important, for evidence is accumulating that that city has already surpassed the population that the Basin can hold. Further increases in carbon monoxide, and other air pollutants, will be dispersed even less readily adding to the increased morbidity and mortality from a host of cardio-respiratory diseases.

We must face the further realization that we do not really know how to solve the political and social problems generated by a city of 10 million, let alone a city of 50 or 20 million. Before we joyously proclaim the increasing magnitude of our cities, we had better be sure we understand the responsibility this entails. At present we do not.

Although DWR's current plans do not call for immediate development of the State's northern rivers, such plans are on the drafting board, as we have discussed. During the past summer the State Water Resources Control Board announced water quality standards for the San Francisco Delta region which were higher than anticipated. Consequently, the Director, William Gianelli anticipates that the Department will need more water than allocated under *Bulletin 160-70* descriptions to meet contract commitments in the Central Valley and Southern California. The most likely source to be tapped is California's North Coast Region. This will produce certain changes, some of which we have discussed earlier, and it is essential that the citizens of the State realize exactly what they are getting and at precisely what cost.

Whether these changes will be beneficial or deleterious can only be judged in terms of human and societal values. From a biological and evolutionary perspective change is neither good nor bad. It merely happens. In fact change constantly occurs in the biological world and organisms either adapt, migrate, or die. The changes which confront them can occur over thousands of years, as in the eutrophication of a lake, or can be cataclysmic, as was the eruption of Krakatoa. Those organisms and species which can adapt survive; those that lack flexibility die. In this way the evolution of species continues.

We commonly hear that eutrophication is an "environmental problem." Such use is ambiguous without clearly stating for *whom* such an event is a problem. While eutrophication forces trout, sturgeon, pike, and walleye to seek another place to live, it poses no problem for the carp, sheapshad, and bream which take their place. Thus, man looking at the situation might say that there is a problem for the trout and other game fish. He might also consider this replacement a problem for himself, since he likes to eat game fish which he can now no longer obtain. He might also say that man experiences a problem when the lake eutrophies because the blue-green algae and bacteria, which now thrive there, produce noxious odors.

Such a state of affairs is obviously not a problem for the microbes; such an environment is ideal for their continued growth and reproduction.

When somebody says that there is an environmental problem, he is usually implying that there is an environmental problem for man. Man's position in nature is unique. Not only does he produce changes in the environment, he also makes value judgments both about the changes he produces and about environmental alterations which other natural events create, as well as the biological adaptations which result. It is only man who can say that a specific natural event is good or bad or that a change which he has wrought is beneficial or not or that the biological adaptations which result from this leave the world any better or worse off then before.

It is important for man to realize that he can produce change in some areas much more rapidly than would occur without his influence. For example, he can cause a lake to eutrophy in decades, instead of millenia. A few people might say that this increased rate of change is good. Others, more oriented toward the idea that man is only one component of the ecosystem, would say that change at the pace *man* sets is deleterious. It is important for those of us who hold this latter view, though, to realize that *we* too have made a value judgment, for biologically a eutrophied lake is neither good nor bad. Eutrophication is merely one stage in the evolution of any lake.

We lack the knowledge to be able to accurately predict the environmental consequences many of our actions generate. This is one fact which is painfully evident throughout our report. Research in the North Coast Region, for example, is totally insufficient to accurately assess the damage to hundreds of species of wildlife which already live there, or to determine which species are likely to move into the new habitat created by our development schemes. Nor do we presently know what the immediate consequences or long range effects of calefaction (making the water warm) from nuclear power plants will be. Man is becoming more and more cognizant of the interrelatedness of living things and is beginning to perceive that changes at lower levels in the biological system affect him as well. Man might very well be producing changes which will ultimately cause his extinction as a biological species. These changes could be sudden, through, for example, our ability to alter environmental conditions with a nuclear explosion. Environmental modifications may also be much more subtle and occur over decades, such as the half century involved in the construction of the State Water Project, or the decade needed to site and build a nuclear power plant, or the near century involved in the eutrophication of Lake Erie. These changes will ultimately work their way through the biological web of life to affect the human species. It is only according to human value scales, however, that they may be judged beneficial or deleterious.

These problems are difficult to report. It is a challenge to communicate information about such slowly developing areas to the public. But this is a responsibility the mass media must take on. The news peg is usually absent; slowly developing environmental stories lack the glamour of the rapidly climaxing situation. These are problems we need to overcome, however, if we are to have an informed citizenry which is able to place the day's events in a context that genuinely gives them meaning and a citizenry which is able to perceive that man is not the center of the ecosystem any more so than earth is the center of the universe.

Biological evolution and the environment are neutral to man's continued presence. Only man can really care about his continued existence on planet earth; whether or not he is there to enjoy them, time and the river keep on flowing.

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Mr. George Buckingham, Alameda County Water District, Fremont. 1/27/71

Mr. John Canadas, Coastside County Water District, Half Moon Bay. 2/2/71

Mr. Eugene Churchill, Public Relations Department, North Marin Water District, Novato.

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Mr. Eugene Huggins, Public Affairs Office, Army Corps of Engineers, San Francisco District, San Francisco. 11/20/70

Mr. Thomas Jenkins, President, Peninsula Water Agency, San Francisco

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Mr. William McLeod, Manufacturing Department, Standard Oil, San Francisco, 12/3/70.

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Mr. John Nelson, Contra Costa County Water District, Concord.

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Dr. Winston Porter, Scientific Development Department, Bechtel Corp. San Francisco, 12/17/70.

Mr. Elmer Ross, East Bay Municipal Utilities District, Oakland, 12/4/70.

Mr. Harry Tracy, Manager, Purification Division, San Francisco Water District, Millbrae.

Mr. Frank Sebastian, Envirotech Corp., Palo Alto.

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Dr. William Bishop, Federal Water Quality Office, Environmental Protection Agency, Alameda, California.

Mr. Willard Branson, Supervisor, Monterey County, Chairman Association of Monterey Bay Area Governments.

Mr. Sidney Brooks, Director, Council of Monterey Bay, Inc.

Mr. Albert Hart, Superintendent, Monterey Water Pollution Control Plant, Monterey, California

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Dr. Stevens Tucker, Professor of Oceanography, U.S. Naval Postgraduate School

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Mr. Raymond Walsh, Project Director, San Francisco Bay-Delta Water Quality Control Program

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